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IV/4 1961

A Planetarium Demonstration in the Classroom

THOMAS D. NICHOLSON, ASTRONOMER

THE AMERICAN MUSEUM–HAYDEN PLANETARIUM

The American Museum–Hayden Planetarium has recently acquired a novel instrument for use in its classes in astronomy and celestial navigation. The device is known as the Musser "Copernican" Planetarium, produced by Scientific Industries, Inc., a firm in Los Angeles, California. A new concept in the visual presentation of astronomy, the device brings into the classroom some of the demonstrations that are possible in a planetarium theater.

The Musser Planetarium bears no resemblance to the traditional planetarium instrument. It is not, as most planetarium instruments are, designed to produce the illusion of a real sky by projecting the celestial bodies and their motions on the inner surface of a sphere. Instead, the Musser Planetarium represents celestial objects on the surface of a flat viewing screen, on which their motions and relationships can be demonstrated. The area within this viewing screen, circular in form and approximately four feet in diameter, is used to portray the planetary system and its motions and the appearance and motion of the night sky. Provision exists for attaching transparent plastic overlays to the viewing screen for demonstrating additional subjects or relationships when illuminated by ultraviolet lamps.

Basically, the Musser Planetarium provides the classroom teacher, or the demonstrator at a lecture, with a dynamic model of the solar system and of the night sky on which he can show the motions of celestial bodies, the principles that govern these motions, and the relationships that arise as a result of these motions. The instrument can be used in any kind of room and needs only a source of electric power. No equipment other than that provided is necessary. The viewing screen is large enough for

most classrooms, and the level of illumination can be adjusted for a bright or darkened room. The Planetarium can be moved about from room to room, or into corridors for exhibit when not used as a teaching aid.

The planetary system, as portrayed on the Musser Planetarium, includes each of the nine major planets, the moon, the region of the asteroids, and the sun. A separate light source produces each of the objects shown, generally by rear projection from inside the cabinet onto the surface of the translucent viewing screen. Each object is controlled by a separate electrical circuit, with provision for dimming, so that the demonstrator can show only those objects that may be required for his purpose. The audience sees the objects of the solar system on the surface of the circular screen and does not see the objects that are not illuminated or the mechanism that produces the motions in the display.

The revolution of the planets around the sun can be shown in either a clockwise direction or a counterclockwise direction, to illustrate the motions of the solar system from above the earth's north pole or from the south pole. The period of a year can be varied in the instrument from five seconds to thirty seconds. The rotation of the earth and the revolution of the moon, the latter in correct ratio with the year, are also illustrated. A clock mechanism keeps track of time as recorded by the instrument, allowing the motions of the planets to be advanced for a specific interval of time, or allowing the lapsed time between the occurrence of various phenomena to be observed. Time can be observed to within one or two days; direct reading to one week is provided.

Scales of distance and size in the presentation of the planetary system are necessarily distorted. Each of the planets is shown by an image of suitable color and markings, where appropriate, to identify it, and their sizes are varied in correct order but not, of course, to scale with one another or with the sun. A correct distance scale, with sun-earth distance

Fig. 1. The Musser "Copernican" Planetarium, demonstrating the bodies of the solar system on the viewing screen. The sun is represented by the bright object in the center of the screen. Earth can be identified by the nearby moon, Saturn by the suggestion of a ring structure. The region of the asteroids shows faintly between the orbits of Mars and Jupiter. Scale of distance is correct to Mars, but not beyond. All major planets are shown.

Fig. 2. The Musser "Copernican" Planetarium, with the star demonstration device on the viewing screen. Illumination can be either white light or ultraviolet. The area within the dark frame shows the stars above the horizon at latitude 40° north, zenith at the center, horizon represented by the curved frame, north at top and east at left. Circles for setting date and time, or local sidereal time, are on circumference of the device. Motion is electrically driven at variable speeds, to represent motion of the stars across the sky.

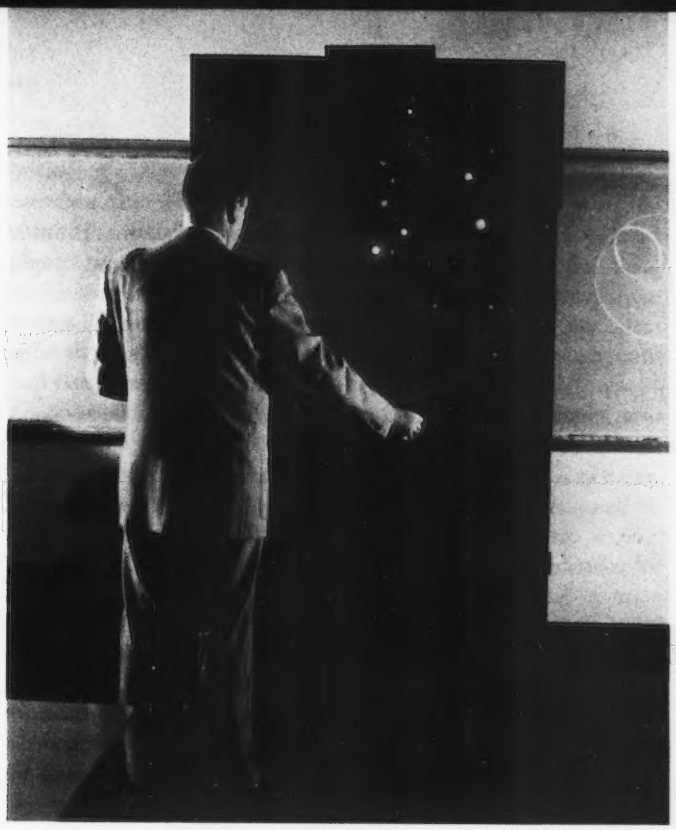

Fig. 1

Fig. 2

taken as unity, is used for the four planets out to Mars, but beyond Mars only the order of distance is shown. The asteroids are shown as a belt of particles between the orbits of Mars and Jupiter, revolving in a period of two and six-tenths years, about the mean for the major bodies of this type. The periods of the planets are in correct scale with the earth's motion, however, and are sufficiently accurate so that the configurations of the planets in nature can be demonstrated for a period of several hundred years.

The manner in which the planetary system is presented in the Musser Planetarium permits the teacher or demonstrator to illustrate a great variety of phenomena, from the very simple to the relatively complex, depending on the level of the audience to which the presentation is being made. The earth, the moon, and each of the planets can be introduced separately, either stationary or in motion, as their features and motions are being discussed. If the teacher wishes to show the configurations that arise between the earth and one or more inferior planets, or with an exterior planet, he can show only the bodies he is describing, produce their motions at variable speeds, stop and restart the motions at any speed to discuss some point, and time the motions over any duration he may wish. Such things as the relationship between the sidereal and synodic periods of the various planets can be shown readily, and these periods can actually be timed to a reasonable degree of accuracy. The relationship between the heliocentric positions of planets and their geocentric positions can be shown, and can even be used to illustrate the manner in which the orbits of the planets can be calculated from geocentric observations of their positions. Thus, for example, the problems solved by Kepler in identifying the orbit of Mars can be traced out on the viewing screen by showing the manner in which the motions of earth and Mars affect geocentric observations of Mars' positions.

Essentially, of course, the instrument illustrates the sun-centered positions and motions of the planets. Geocentric relationships must be pointed out by the demonstrator. A unique auxiliary device, however, converts the presentation of planetary positions and motions from a heliocentric to a geocentric point of view. This device places an earth-centered coordinate system over the viewing screen and controls the coordinate system so that the origin of the coordinates always rests on the earth, whether the earth is stationary or revolving at any speed or direction. The coordinates show the angular displacement measured from the earth, between the sun and each planet, and the distance between the sun and each planet. As the earth and the planets revolve on the screen, this coordinate system shows clearly the manner in which the distances and directions of the planets are changing as seen from the earth rather than from the sun. This form of demonstration is accurate, of course, only for the planets

out to Mars, the orbits of which are shown in correct proportion to the size of the earth's orbit. The coordinates on the attachment are painted in ultraviolet pigments so that they become visible only when the ultraviolet lamps of the device are turned on. Under ordinary lighting, these geocentric coordinates are not visible to the audience, hence do not interfere with the discussion or demonstration of the planetary system until their use is desired.

The ultraviolet illumination that is provided with the instrument also makes possible the use of transparent plastic overlays on which additional celestial bodies and other relationships can be shown by means of ultraviolet reactive pigments. When these plastic overlays are superimposed on the viewing screen, the bodies or relationships illustrated on them become part of the presentation of the solar system. The orbits of the planets, for example, can be traced out as the planets are observed moving in these orbits. The path of a space probe from the earth to some part of the solar system can be identified, and the relative motions of the earth, the planets, and the space probe from the proposed time of launching to any time later can be followed. The circumstances that actually took place for some specific interplanetary vehicle can be set up on the screen and demonstrated. Cometary orbits, in relation to other objects of the solar system, can be superimposed over the viewing screen in this manner, and the problems and circumstances of observing comets from a moving earth can be shown. It is simple to illustrate, for example, why certain comets, approaching perihelion from behind the sun as viewed from earth, might be completely unobserved from the earth. The phenomena of meteor showers is very well demonstrated this way as well, permitting the teacher to illustrate the factors that cause showers to recur annually, that produce daytime counterparts to some showers, and that govern the duration of showers, the variations that sometimes occur from year to year, and the velocity of the shower meteors that reach the earth. Plastic overlays can be prepared in advance or can be developed in place by the demonstrator. Subjects can be drawn on the plastic by ultraviolet paints, for permanent materials, or by means of special wax pencils with ultraviolet pigmentation, in which case the sheet can be easily cleared and reused.

The demonstrator has the option of demonstrating planetary phenomena in true time or in relative time. In relative time, he can take the planetary positions as he finds them and advance or retard these as he wishes. Specific planetary arrangements, not necessarily those current in the sky, can also be set up in advance, so that the motions in the future will illustrate some desired problem. By reversing the motion of the planets, the demonstrator can return the system quickly to the initial setting if he wishes to repeat the problem. The instrument can also be adjusted, however, to

show the positions of the planets at any true date. Provision is made for setting the planets to their correct positions on January 1, 1960. The motion of the instrument will then maintain the correct relative positions of the planets into the future or the past for many centuries. By this means the demonstrator can show, for example, the planetary conjunctions and oppositions that will take place in the future, or the alteration of the planets from evening to morning stars. Reversing the instrument will also return the planets to the initial positions in true time.

A special attachment for the Musser Planetarium converts the viewing screen from one that shows the planetary system to one that shows the features of the night sky. The attachment locks in place over the viewing screen. The stars that are visible above the horizon for any date and time are shown inside a curved frame which represents the horizon at 40° north latitude. The stars are painted in ultraviolet pigments so as to be visible under ultraviolet illumination. All stars to the fourth magnitude are shown, and selected stars to lower magnitudes are included where they contribute to the form or geometry of constellations. Where appropriate, the colors of the stars are shown.

Setting circles on the attachment permit the demonstrator to arrange the sky for the date and time required. When the device is set, the stars visible inside the transparent frame are those that would be in the sky at that time for any place at 40° north latitude and, without appreciable error, within 5° north or south from there. The zenith is located at the center of the transparent frame, the edge of the frame represents the horizon, and the meridian extends vertically through the frame, with north at the top and east to the left, so that the stars appear as though one were

Fig. 3. The Musser "Copernican" Planetarium, used as a display device with a print of the moon on the viewing screen. The print is made with special pigments that react to ultraviolet radiation, to enhance the illusion of depth in the picture when viewed in a darkened room. Similar prints of other astronomical subjects are also available.

Fig. 4. The Musser "Copernican" Planetarium, showing the method of placing various overlay materials over the viewing screen to define objects or relationships not apparent on the screen. The author is shown (left) with an overlay to represent various types of orbits for objects in the solar system. The designer, C. O. Musser (right), holds the device that places a geocentric coordinate system over the planet viewing screen to emphasize earth-centered phenomena observed in the solar system. The overlays lock on top of the viewing screen by a simple arrangement of arms. The geocentric coodinate device rotates mechanically to keep the center of the coordinate system on the earth regardless of the speed or direction of planet motion. Other overlays are also available, or can be developed by the operator.

Fig. 3

Fig. 4

facing south and looking straight upward. The rising and setting of the stars and their motion across the sky during the night are shown by a motion from left to right, or counterclockwise, across the face of the viewing area. Setting circles are large and easily read by the operator, divided so that the sky can be set to the nearest five minutes in time or any date. Setting can also be made by means of a scale of local sidereal time. The rate of turning of the stars is such that would produce a day in periods from one minute to six minutes. The motion of the stars can be used to illustrate the westward shift of the constellations during the month as well as the diurnal motion of the stars.

Again, the device can be used for demonstrations that range from the simple to the complex, depending on the nature of the audience. The rising and setting of the stars, the constancy of the polar star, the circumpolar motions of stars in the northern sky, and even star identification methods can all be shown readily. The elements and coordinates in the horizon system and in the equatorial system of celestial coordinates can be shown by tracing with ultraviolet wax pencil on the transparent face of the star field. Factors that affect the time and direction of the rising and setting of celestial bodies, the manner in which bodies change in altitude and azimuth, and the principles that govern the altitude and time of meridian passage can be illustrated. The astronomical triangle used in solving for time, longitude, altitude, and celestial lines of position can be drawn in place on the sky, and the manner and significance of its solution demonstrated. An actual problem in spherical astronomy can be set up and its solution scaled off. To facilitate the construction of relationships over the area of the visible sky, coordinates and coordinate lines are imprinted lightly on the star field, so that they are visible to the demonstrator but not to the more distant audience.

The features and methods of presentation built into the Musser Planetarium provide the teacher in astronomy or in celestial navigation with a very versatile instrument right in his classroom, an instrument on which he can show many of the motions and relationships that students find most difficult to grasp and to visualize. No special instruction or training is required for its use. Little or no explanation of its features, other than a description of the demonstration, is required for the viewing audience, because the presentation is generally uncomplicated and self-evident. Controls for the various projectors, motions, and methods of illumination are conveniently and simply arranged on the front of the cabinet beneath the viewing screen.

The cabinet for the device is arranged vertically in two sections. The upper section houses the electrical and mechanical equipment that produces the various effects, with two large access doors in back and the viewing screen and control panel in front. The lower cabinet serves as

storage space for the auxiliary devices, the transparent plastic overlays that are provided, and such things as pointers, wax pencils, and spare lamps. The two sections of the cabinet are bolted together for rigidity. In over-all dimensions, the two cabinets stand four feet high, three feet wide, and two feet deep. The total weight of the cabinets is about four hundred pounds, but the lower cabinet rests on casters so that it can be moved. The upper cabinet, containing the display, can be easily detached and displayed elsewhere than on the lower cabinet, to reduce over-all height.

At the American Museum–Hayden Planetarium, the Musser "Copernican" Planetarium will be used principally as an aid in teaching classes in astronomy and celestial navigation, although it may occasionally be used as a corridor display or in connection with special lectures or demonstrations in the large double classrooms where courses are taught. The program of courses offered at the Planetarium includes nineteen separate courses in astronomy and navigation for the current school year, some offered in both fall and spring semesters. Courses at all school levels, from primary grades through college, and for the general adult public are included among the offerings.

Problems of Museum Architecture[1]

A. E. PARR, SENIOR SCIENTIST
THE AMERICAN MUSEUM OF NATURAL HISTORY

If we were to speak in the same tense of the demands that the museums of today place upon architecture, and the answers that architecture is able to offer to meet these demands, we would be logically inconsistent. A demand must be made before it can be met. The museums of today are the answers to the demands of yesterday, and the demands we make now must be answered by the museums of tomorrow. The task of those concerned with the operation of museums must therefore be that of trying to anticipate and define the needs of the future as goals for the creative genius of architects in the present.

To begin with, let me say that the architectural needs of museums are not universal but peculiar to each institution. To speak of these needs in general terms, and attempt to formulate recommendations applicable in common to the wants of all, would therefore be both presumptuous and illogical. But there are universal factors that have be to taken into account by every museum in determining its own particular and unique requirements, and the questions posed by these cosmic variables may well form the basis of profitable discussion among all concerned with the future of museums.

Since all construction must be preceded by the acquisition of a site, and all planning must be influenced by the nature of the plot, it seems logical to start with the problems of location. By a carry-over of traditions of grandeur from the days of limited audiences with unlimited leisure, many museums around the world have been doomed to the pomp and circumstance of splendid isolation in great parks and open spaces withdrawn from the hurly-burly of vulgar human tasks and pleasures. Museologists have tried to rationalize this condition by hopeful allusions to the

[1] Paper presented on May 25, 1961, at the Conference on Museum Architecture held by the International Council of Museums in Turin, Italy.

"pleasurable stimulus of expectation" created by distance and pastoral surroundings. Whether high expectations improve the impact of the museum's own presentations is very questionable. More utilitarian references to an escape from urban dust in sylvan fields may have had their justification in the days of horse-drawn carriages and unpaved roads. But now that the streets are sealed under asphalt or cement, and the grime of the cities takes the principal form of air-borne pollution carried many miles from its source, the space of a park gives no shelter from the dirt that descends from above.

The contagion of stately retreat would seem to have been more epidemic in America than elsewhere, but cases can be found in all parts of the world, and it is interesting to note that banishment to the outer environs, or at least from the heart of the city, seems to have been far more universally inflicted upon science museums than upon the institutes of art. This differential treatment of sister institutions has reached extremes in such cities as Oslo, Stockholm, or Detroit, and at ICOM conferences, but may also be observed in milder forms in Paris and Chicago, to mention only a few examples.

Until the middle of this century it was quite fitting to speak with derision about the disadvantages of pretentious locations. Progressive thought would favor locales that were easily accessible to all, or at least to the largest possible random sample of the population, without special effort or inconvenience. Central spots, particularly in areas of shopping, entertainment, and other occupations of leisure time, were highly regarded, although only rarely secured for museum use. The desirability of being where the crowds stroll by still holds today, but in many parts of the world we now have a choice to make between strollers on foot and strollers by car, and the same alternatives will soon face museum planners everywhere.

To say that we should be where the crowds are in no sense whatsoever implies a commitment to the idea of quantitative mass education rather than qualitative improvement of the individual. It merely recognizes the fact that no one can know whether he would like good wine until he has tasted it. One often wonders how many there are who might have had their lives greatly enriched and their value to society increased if they had ever come upon a museum in their casual path. If we want all who come to us and all who stay away to act by choice and not by chance we must give all a chance to choose.

Among the possibilities and realities of museum sites are central locations in the hub and hubbub of metropolitan activities, off-center urban locales in residential neighborhoods reached mainly on foot or by common carrier, peripheral suburban spots where the visitors would mostly arrive by private car or special transportation, and, finally, we may always

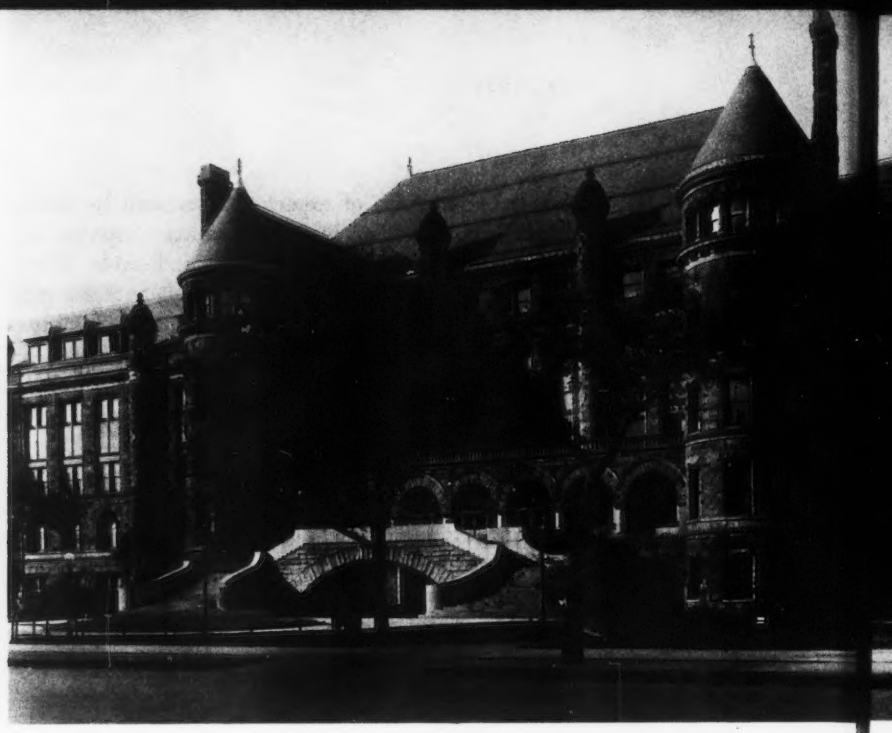

Fig. 1

have to contend with the temptations of poor but stately locations that would be shunned by any establishment realistically cognizant of its own needs to be in the presence of the public.

A basic question that must be answered before a site is selected concerns the possibility and desirability of having many small or only a single large museum or a combination of both. It is obvious that if a central location is avoided, a multiplicity of institutions will ultimately be demanded. In an interesting study of museums in the United States, Rea[2] has shown that the larger the community is the smaller is the percentage of its members that will attend a single, central museum. Rea's investigation also demonstrated that as the museum and its budgets grow larger the cost per visitor does not diminish. On the contrary, it tends to increase in a quite substantial way. In other words the continued growth of a single central institution brings diminishing returns according to all quantitative methods of measurement.

The high value of the land also argues against having the museums

[2] Paul Marshall Rea, "The Museum and the Community." Science Press, Lancaster, Pennsylvania. 1932.

Fig. 1. Two façades of The American Museum of Natural History.

compete for space in the areas of the city where this competition is most intense. Added to the painful direct cost of securing the site are the undesirable secondary effects of being forced to plan the museum in height, rather than in width, except in the rare instances when economic factors need not be given too serious consideration.

There are many good reasons for objecting to the upward extension of exhibits through two or more floors. Museum fatigue has become a tiresome subject to all concerned with museum functions, but it is not a topic that can be avoided. There can be no doubt that the need to move from floor to floor, whether by stairs, elevators, or escalators, increases the wear and tear of a museum visit. Each ascent or descent disrupts the normal flow of a visitor's experiences and activities in the museum, calls upon him for a new decision, and gives him opportunity to become aware of the drain upon his energies. There is nothing more tiring than a feeling of fatigue. That this is not merely an academic rationalization is amply demonstrated by the records of generally diminishing attendance from floor to floor in the upward direction, regardless of the facilities offered for vertical transport, except when very special attractions are offered at upper levels to counteract the trend, or when other unusual circumstances prevail.

Multilevel space for display also puts great obstacles in the way of

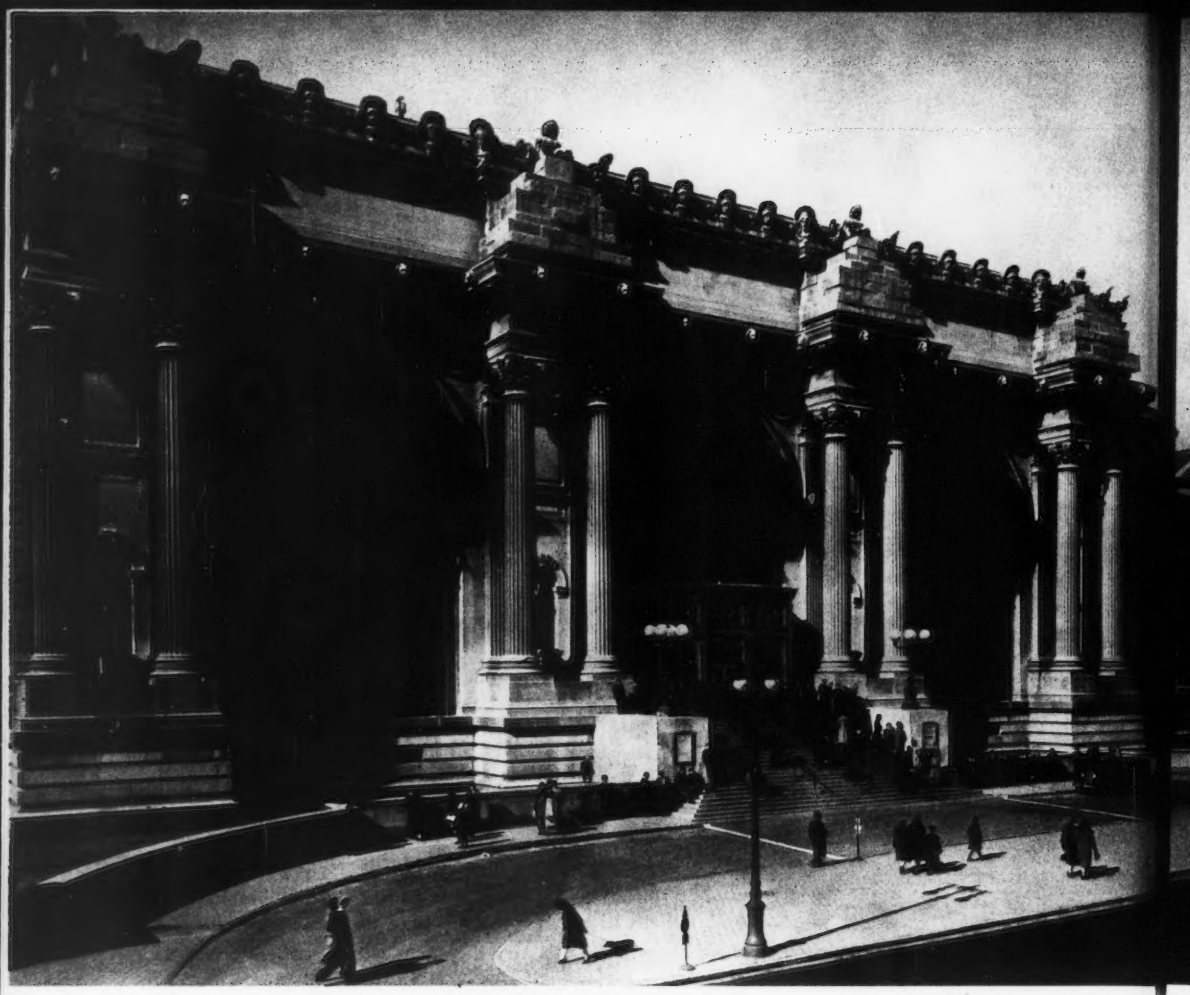

Fig. 2

achieving a rational sequence of exhibits that will sustain the observer's interest and give him a sense of continuity as well as a stimulating change of pace throughout his experiences in the museum. The problem is one of simple mathematics. With a single entrance to a single floor it is possible, but in the writer's opinion not advisable, to restrict traffic to a single route in a single direction. Allowing minimum freedom of choice, at least two different sequences will be followed by the public in its contemplation of the exhibits—from right to left, or from left to right; from beginning to end or from end to beginning. Add another floor, but use a single stairway and we have a minimum of two times two, or four, alternative routes which it will be perfectly normal for the public to follow. Even under such simple circumstances, a four-story exhibit will have to reckon with a minimum of 2^4, or sixteen normal visitors' routes. With two entrances and two stair-

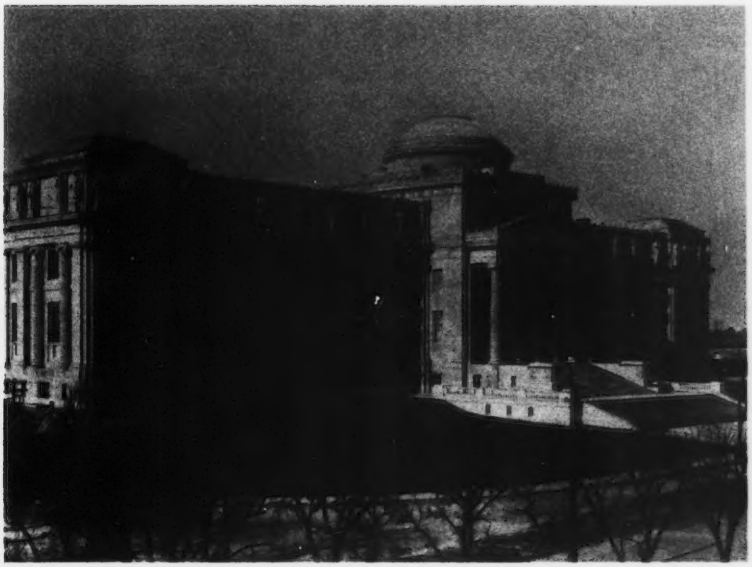

Fig. 3

Fig. 2. Main entrance to The Metropolitan Museum of Art.

Fig. 3. Brooklyn Museum before and after removal of exterior stairway.

ways, instead of one of each, the number of normal routes through four stories becomes 4^4, or 256. It is quite certain that no human brain, and very doubtful whether any electronic substitute, could ever devise a story that would read equally well in 256 different arrangements of its paragraphs and chapters. It is no wonder therefore that museums forced to seek their growth in height and not in width have developed an astounding indifference to *non sequiturs* in their presentations. Of course, *non sequiturs* can be charming, and changes of subject are probably essential stimulants of renewed interest in a large museum. But innovations that are charming or stimulating in one sequence cannot possibly be equally charming and stimulating in 255 other progressions and are bound to be quite disturbing and discouraging in many of the normal suites of experience of a museum visit.

There is one possible solution to the dilemma of exhibition in height which has intrigued the writer for a very long time, namely, the use of a square or rectangular spiral. This is a vulgar, low-bred spiral born of practical considerations, with no mystique in its ancestry. It is not my intention to disparage the esthetics of the spiral. In fact, I am a passionate admirer of its most famous architectural application, which moves me with the stunning impact of a beautiful woman without a sensible thought in her head.

A more utilitarian spiral may be thought of as a series of gently sloping, long, rectangular display areas connected through horizontal squares at the corners so as to form an uninterrupted ramp around a solid central core containing auditorium and smaller lecture halls, library, storage for study collections, and other facilities. There would be only one possible general route to consider in the exhibition plans, although there would be free opportunity for a visitor to limit his visit to any section he might prefer. The public would be lifted to the top of the spiral at the start and would be walking downhill all the way, without being challenged to make repeated and confusing decisions about direction, up or down, right or left, or straight ahead. When the writer privately compared the possibilities of such a spiral with the post-war architectural plans being developed for The American Museum of Natural History during 1942–1944, he was surprised to find how easily the spiral-*cum*-core lent itself to the solution of a great variety of practical problems, but at this point it must suffice to mention that it would require only about one-fourth of the ground area and no more than twice the height for such a form to be able to accommodate all the functional space requirements that more traditional architecture would provide for.

However, the utilitarian spiral remains untested by actual experience, and, so long as we have no other solution of proven merit, the economic and other factors that have just been discussed must be taken to weigh

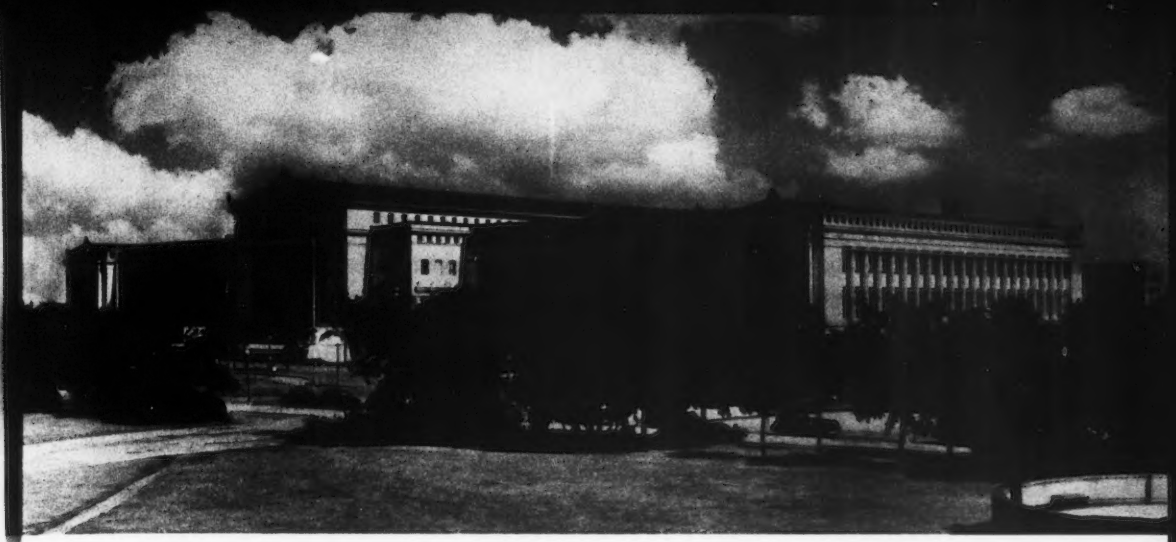

Fig. 4

heavily in favor of planning a spreading network of museums of deliberately limited size, strategically placed throughout the urban and suburban areas, rather than a single, centrally located and expanding institution. But there are also qualitative considerations to be taken into account. Those who benefit most from the neighborhood exhibits will sooner or later reach the point where their further development, even as laymen, requires more than any unit of a more or less evenly dispersed establishment will ever be able to offer. And where could the scholars find satisfaction for their needs if there were no assembled collections like those of the Vatican, the Louvre, the British Museum, the Prado, the Metropolitan, and The American Museum of Natural History? These conflicting desiderata seem to point quite clearly towards a future solution for the museum problem that will be quite similar to the system of large central reference libraries with smaller local branches[3] that has already become familiar in most of the metropolitan regions of the world. Perhaps these comments may seem remote from our subject, but, though we may be called upon only to plan the first gallery, it is well to pay heed to all the thoughts and circumstances that may shape the future of all museums in the community, including the one of our own creation.

Many secondary and mundane considerations devolve upon the choice

[3] For further remarks on branch museums, see Rea, *op. cit.* pp. 173–174, and Parr, "Why Children's Museums," CURATOR, vol. III, no. 3, 1960, especially pp. 235–236.

Fig. 4. Chicago Natural History Museum. Thirty-eight stairs lead up to main entrance.

of location, with consequences impinging upon the architectural problems. It would be an unforgivable mistake to plan a future museum in any part of the world today without ample accommodations for private cars and for buses or other special public vehicles to the extent of all reasonable demands within a foreseeable time to come. In central metropolitan situations such as that of the Louvre in Paris, the Museum of Modern Art, or the Central Reference Library in New York, any insistence upon space for separate individual conveyances may well be treated as spurious or unreasonable, but buses bringing groups of visitors from schools or outlying districts create problems even there, which scarcely any museum has as yet resolved. In a network of urban neighborhood museums the vehicular problem would be likely to be at a minimum, although not non-existent. In stately locations and suburban environments the genuine needs are great and rapidly growing, but fortunately often amenable to solution within the natural horizontal dimensions of the plot instead of the structural vertical dimensions of the architectural plan.

Other facilities for comfort and pleasure conveniently available outside in the immediate surroundings also affect the inside needs of the museum. It is extremely difficult, at least in America, to operate a one-meal restaurant of a quality and atmosphere appropriate to the dignity of a cultural institution without experiencing a substantial loss, particularly when the only meal that can be regularly served is lunch. In a central location the need of such service within the museum can be eliminated entirely, but this is, perversely, also the situation in which the loss can be most easily converted into a substantial profit, particularly if the architectural plans make the restaurant a link between the inner and outer worlds, equally visible and accessible from both. The public relations value of a good and attractive eating place is also an important asset that may well warrant some expenditure, if loss cannot be avoided. In the museums that already exist there is, by and large, perhaps no problem that has been so badly neglected or mistreated architecturally as the problem of how to feed the visitors with dignity, pleasure, comfort, and convenience. Let us hope that the architects of our future institutions will be able to do much better. Looking ahead, one must also be forewarned that as the museum habit spreads the demand for a quick and inexpensive snack will grow even faster than the need for a more comfortable meal, and this is a demand that will also have to be met in a manner commensurate with the cultural status and esthetic standards of the museum. This presents even more difficult architectural and administrative problems than those of traditional restaurant service, and such problems are already pressing hard upon many museums, particularly those in stately locations.

Museums commonly take an ambiguous attitude towards other establishments competing for the idle hours of the public. They deplore the

competition of "less worthy" attractions at the same time as they refuse to accept it and do not seek to realize the genuine advantages that such "competition" might offer. If we wish the museum's influence to be widely felt, the lack of other enticements in its immediate vicinity may actually be a severe handicap. A knowledge that there is nothing else to turn to if the museum should disappoint, or when museum fatigue sets in, is not encouraging to potential callers, and perhaps even particularly not to those who have already had some experience with the strains of a museum visit and with their own ability to endure them. It is one of the great weaknesses of stately locations that they almost force the public to think in terms of "sacrificing" a day, or at least an afternoon, for a visit to the museum, with no other pleasures within reasonable reach, when their museum appetite has been satisfied. These observations have a direct bearing upon questions of museum architecture because it would serve little purpose if we were to decide that our museum ought to be where the crowds drift by and did not also endeavor to give it a façade that would tempt a multitude to enter.

Architecturally the museums are undoubtedly the scions of palaces, and palaces descended from castles. The functions of the ancestral forms were not to invite and reveal but to repel and seclude. In their architectural mien even the most modern museums of today are generally true to the traditions of their lineage, however little their architectural features may retain of the family resemblance. It should be just as natural to enter a museum as it is to enter a store, a bank, or a bakery. Nevertheless, I venture the opinion that, for example, the plaza and ground floor of almost any of the attractively designed new commercial buildings on Manhattan Island would offer a more inviting approach and entrance to a museum than any museum in New York can boast of presenting today, whether it be ninety years of age or only two years old. We must demand of the museum architecture of the future that it reverse this relationship, or, at least, remove our handicap. Our appearance should be gay without being frivolous, informal without being inelegant, and seductive without being undignified.

Among the many forbidding aspects of traditional museum architecture is the prevalence of exterior stairways for the visitor to climb before he can reach the august sanctuary of his destination. These status symbols of devotion to the higher things in life would seem to have gained special and unusual currency among the designers of museums until quite recent times. Although there may also be lesser entrances giving easier access to the venerable precincts within, the condescending hauteur of stairs reaching down into the outer world remains the dominant architectural expression of the façade that is turned towards the public.

Few other establishments have indulged themselves in this particular

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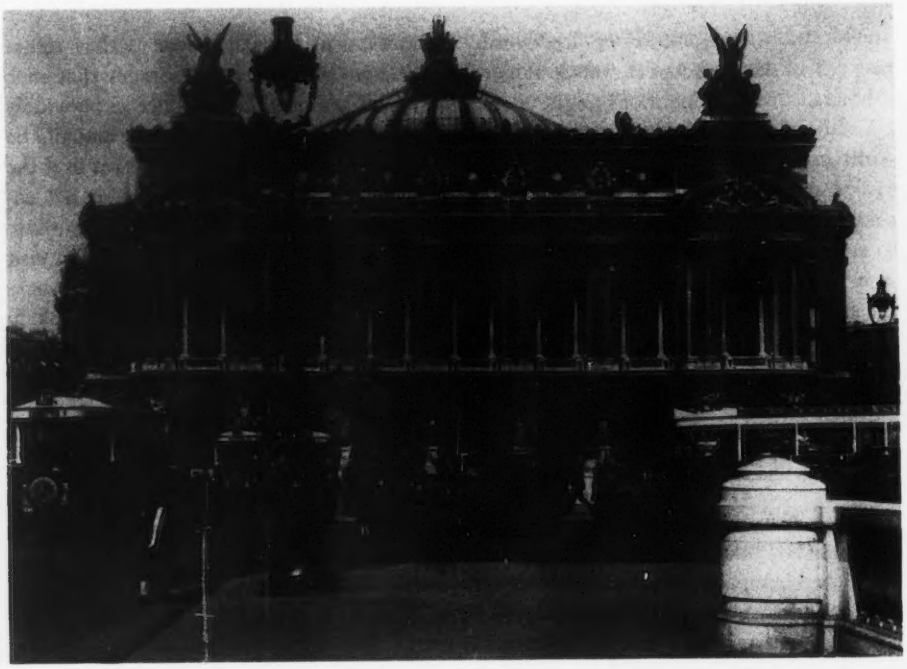


Fig. 5. Main façade and interior grand staircase of the Paris Opera.

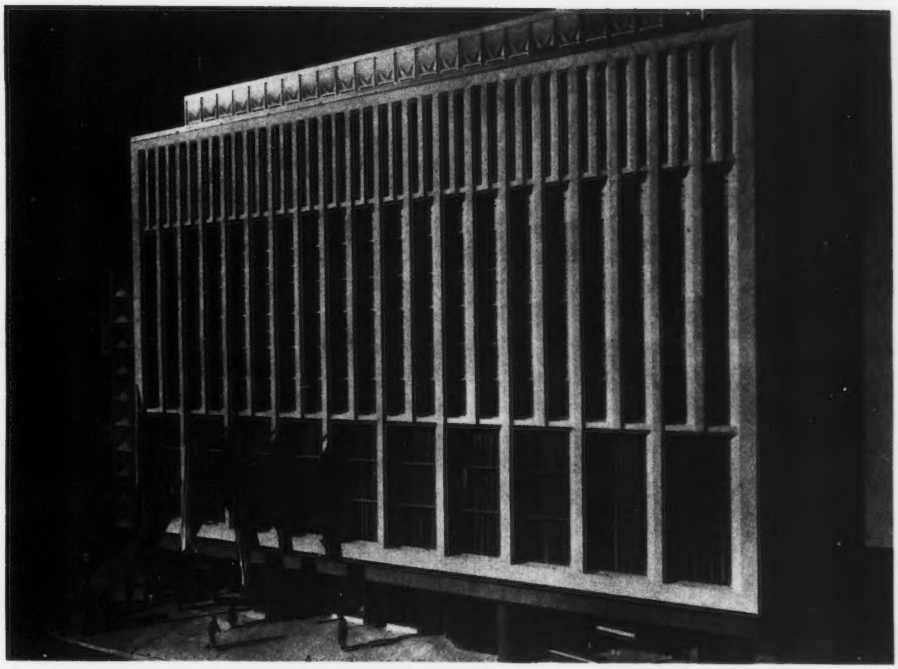


Fig. 6. Republic National Bank of Dallas, Texas: entrance façade; interior stair and escalator.

form of conceit. Even a century or so ago, before most of the staircase-adorned museums that confront us today had yet been built, other fine edifices, such as opera houses, theaters, and the great magazines of commerce, seeking to attract the public into their halls and passages, generally had the courtesy and good sense to take you inside and give you shelter before offering you the challenge of their awesome grand staircases. And the same thing will be found in the most modern of commercial establishments faced with a need to conduct their business above the level of the sidewalk. The new Republic National Bank of Dallas may serve as a fine example.

The peculiar addiction to exposed and ostentatious stairways so prevalent among museums is difficult to justify on any rational basis, but perhaps fairly easy to explain when we remember that the temples of antiquity must be included with the palaces of later centuries in the ancestry of museum architecture.

While many museums have now come down to the ground, it is very doubtful that they are actually catching up with commercial structures in the development of a friendlier and more relaxed architectural approach to the public. The museums have moved, but others have moved faster. Pictures may serve better than descriptions to illustrate this point.

The new branch of the Manufacturers Trust Company in New York may be said to have dropped all visual barriers between its engaging interior and the passers-by on the sidewalk, drawing their attention with the attraction of an unfenced public garden.

The style of the market place would, as a rule, not be directly applicable to the design of a museum. But the very modern building of a department store in Denver would seem almost equally ideal for the display of a museum's treasures and for the sale of merchandise. A completely glass-walled low annex, with the main entrance to the entire establishment, reaches out into the public plaza, like a welcoming hand holding forth to covetous eyes samples of the hoard to be found within. The well-proportioned bulk of the main building is windowless, except for a frieze of display windows at ground level, extending the invitation of the annex. A museum could move right in and be very happy with its premises, and museum planners might learn a lot from buildings such as these.

When I express myself somewhat unenthusiastically about the merits of currently modern museum buildings, I wish to make it perfectly clear that I have the greatest esteem both for the esthetic qualities and for the functional advantages of many of the edifices I have specifically in mind, and that I would not presume to criticize their architecture any more than I would criticize the beauty of Mont Blanc. I merely wish to suggest that the top of Mont Blanc is no place for museum exhibits.

We have talked of central versus other locations as if the center of daily

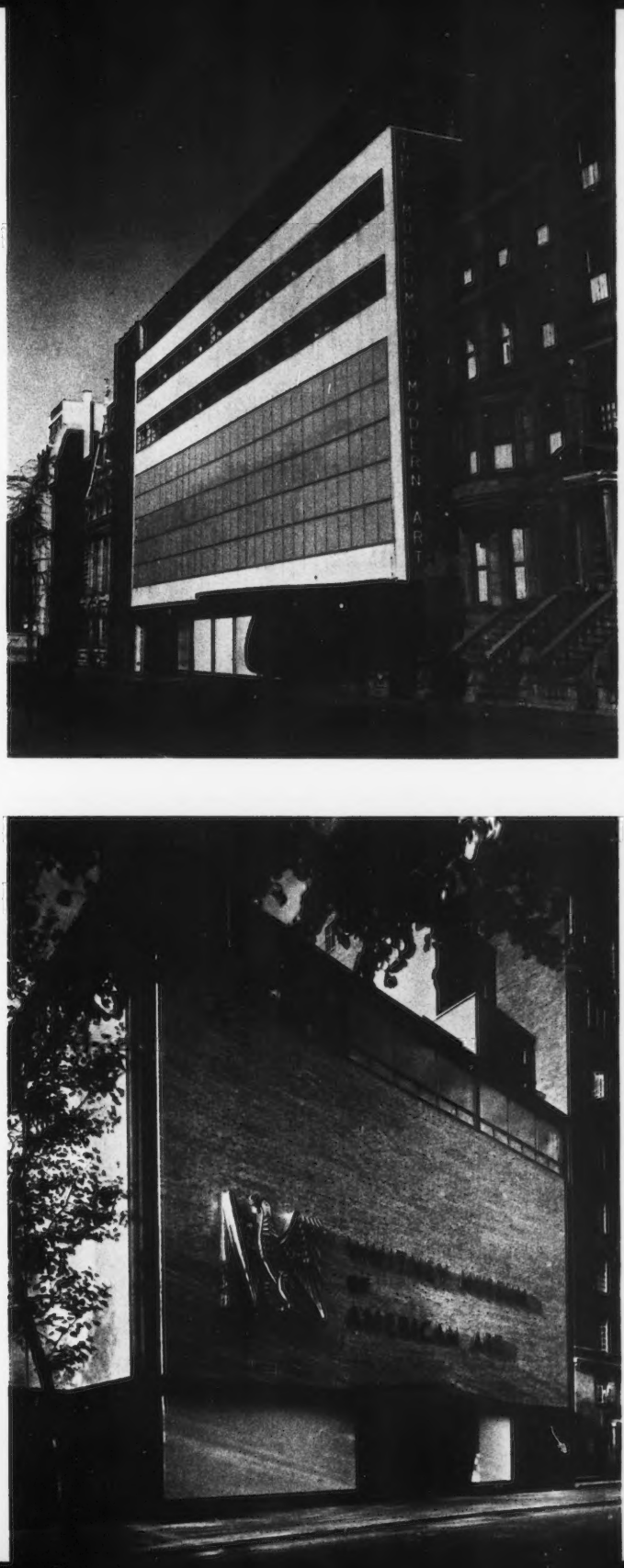


Fig. 7. Museum of Modern Art (above) and Whitney Museum of American Art (below).

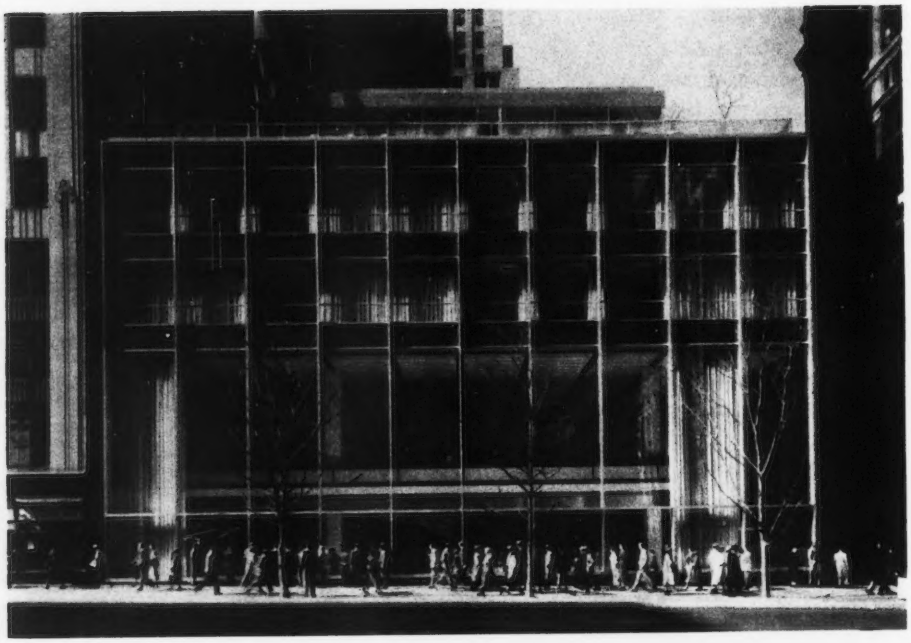


Fig. 8

life in a community were easy to find and would always remain where we found it. There are cities in which topographic features or man-made landmarks make it difficult to imagine any extended shift of the center of activities, but there are other municipalities that have experienced a continuous movement of their dynamic centrum almost from the date of their founding. If there is no assurance of permanence for the advantages we seek in whatever type of location we choose, it is difficult to avoid the unpleasant duty of questioning the palatial tradition of permanent edifices which still reigns unchallenged in museum architecture. Perhaps the temporary concepts of utilitarian structures would serve us better in the long run than the immutable monumental conceits inherited from a world without toil. In the contemplation of this possibility we must not, however, lose sight of the fact that there are some museums that not only in their collections, but also in their premises partake of the character of national or cultural shrines. Even though they may not occupy historically hallowed ground, permanency of location and buildings can become an essential feature of their appeal and of the traditions they represent. The subject of such institutions will concern us again in another context. In the meantime we must inquire into the internal circumstances that may permit or prevent the mobility suggested by demographic considerations. In this connection the functional relationship between exhibits and study or storage collections is a matter of great importance.

In a natural history museum the fish we display to the public is preferably and usually only a cast or a model, costlier and more valuable for its purpose than a true specimen, but not of the slightest usefulness to the scientist, who bases his research on the storage collections. While no man can pretend to know the problems of all kinds of museums, certain conclusions are so obvious that one need not hesitate to draw them. In a gallery of art we certainly expect to find exhibited the best and most important, perhaps even all the Cezannes, Gauguins, or Rembrandts in the collection. To an outsider, at least, it therefore seems obvious that the paintings shown in the public galleries of a Louvre or a Metropolitan Museum must always remain a primary part of the scholarly treasures of these institutions regardless of whether they also keep other collections of secondary rank in study reserves. This is a condition diametrically opposed to that which obtains in the relationship between exhibits and research specimens of fishes in a museum of natural history, as we have already

Fig. 8. Fifth Avenue office of the Manufacturers Trust Company. The optical fusion of inner and outer space, enjoyed by the eye at all times, is best seen by the camera at night.

Fig. 9

seen. Judging by the actions of some museums of art, there may even seem to be room for doubts about whether it actually is desirable for these institutions to keep large collections of secondary examples of the pure arts in storage, withdrawn from public view, although other categories of objects which also have an ethnographic, archeological, or technological significance must undoubtedly be retained for scholarly purposes in larger quantities than could possibly be placed on parade before the general public. Depending upon the subject and the objects of a collection, all kinds of intermediate situations between the two represented by art museums and by museums of natural history could also be described, but there is no need to go into the details for the purposes of this discussion. It might be mentioned, however, that in many of the general or special

Fig. 9. May-D & F department store in Denver, Colorado. General view.

Fig. 10. Detail of May-D & F department store.

museums of industry and commerce there would seem to be a deliberate avoidance of accumulations that cannot be put on view.

It is, of course, a matter for each museum to determine its own needs of study collections not on exhibition, and to decide upon the feasibility of divorcing and widely separating storage from display. But it should be pointed out that the creation of large repositories for scientific research collections in less expensive locations remote from the metropolitan locales of exhibition halls has been seriously suggested several times. It is also difficult to avoid a slight suspicion that one might find some museums that have already acted upon the idea, but have made the mistake of bringing the exhibits along with the research collections into regions where few visitors will venture.

The architectural requirements of storage and display are, of course, completely different; and the movement of a storage collection, at least if it is the kind of research collection with which I have experience, is actually a far more formidable task than the reinstallation, modernization, and replacement of exhibits in a new location. When we try to envision the future I would therefore strongly suggest that we should always give careful consideration to the possibility that the enduring needs of a museum might best be met by a dual rather than a single architectural solution of its problems. Storage and laboratories may, without practical objections, rise to great heights like the stacks of a library, and the obtrusive columns of traditional cubicular architecture create no difficulties.

Fig. 10

Nor would this unit of the museum complex ever be in danger of outliving its usefulness because of socio-economic changes in the environment in which it was built. It may therefore be quite logical to consider a far more lasting structure for storage than we plan for display, regardless of whether the two be connected by corridor or only by common carrier.

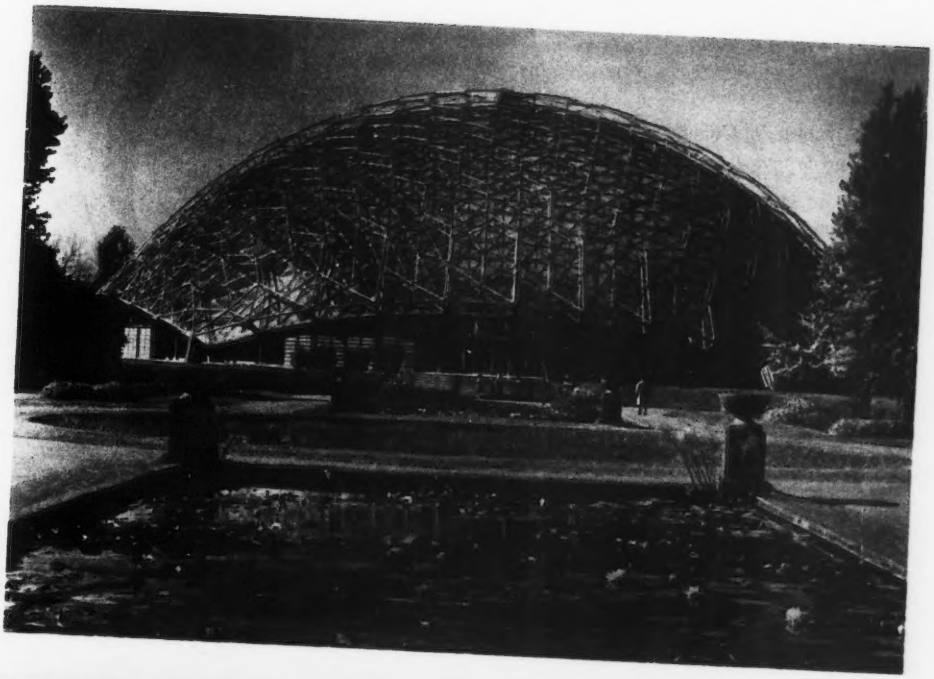
When we speculate upon the possibility of impermanent shelters, at least for the exhibition aspects of museum functions, we think of financial rather than physical mobility, of frugal rather than prodigal styles and methods of construction that will never make it economically unthinkable to abandon old quarters for new. The idea may not be very appealing to most architects, but it may, in this connection, be well to remember that progressive museums today use architectural services in two quite different fashions. The architects who devise the endless transformations of museum interiors that are required to meet the changing needs of new exhibits or of evolving display techniques must be satisfied to seek fulfillment in creations as ephemeral as the products of the stage designers' art. There is scarcely any compelling reason in justice to yield to their brethren who plan our exteriors the privilege of burdening our future with personal monuments as permanent as the Pyramids.

The degree of impermanence that can reasonably be contemplated according to prevailing circumstances is, of course, relative. Ideally the exhibition buildings of any museum must, of necessity, last much longer than the temporary pavilions of international expositions, but not so long as the Tower of London, and perhaps only rarely quite so long as the Crystal Palace.

An architectural form that is equally adaptable to temporary and to permanent locations and purposes is already available in the geodesic dome. The weather-controlled greenhouse, or Climatron, of the Missouri Botanical Garden in St. Louis is the largest and most spectacular example of geodesic construction. Museum designers will do well to bear in mind the practical and esthetic effectiveness of this airily impressive edifice. It is also of interest to note the independently developed similarities of the exhibition plans for the living plants in the Climatron, and for the artificial habitats in the ecological halls of the proposed new Natural History Museum of the National University of Mexico.

In regard to both physical and psychological demands upon the design of exhibition space we also find extreme differences beyond possibility of universal generalizations. Perhaps it is in the museums of science and industry

Fig. 11. Climatron greenhouse of the Missouri Botanical Garden in St. Louis, by day and by night.



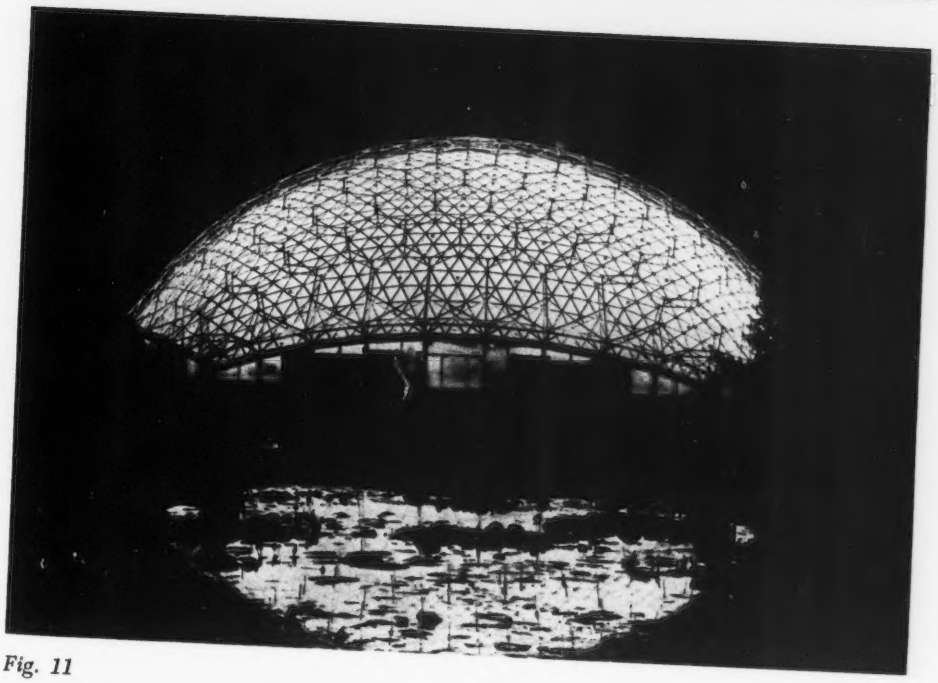


Fig. 11

Fig. 12. General plan of ecologic botanical exhibit in Climatron.

Fig. 13. Interior of Climatron of Missouri Botanical Garden.

Fig. 14. Interior of Climatron, with entrance to under-water passage.

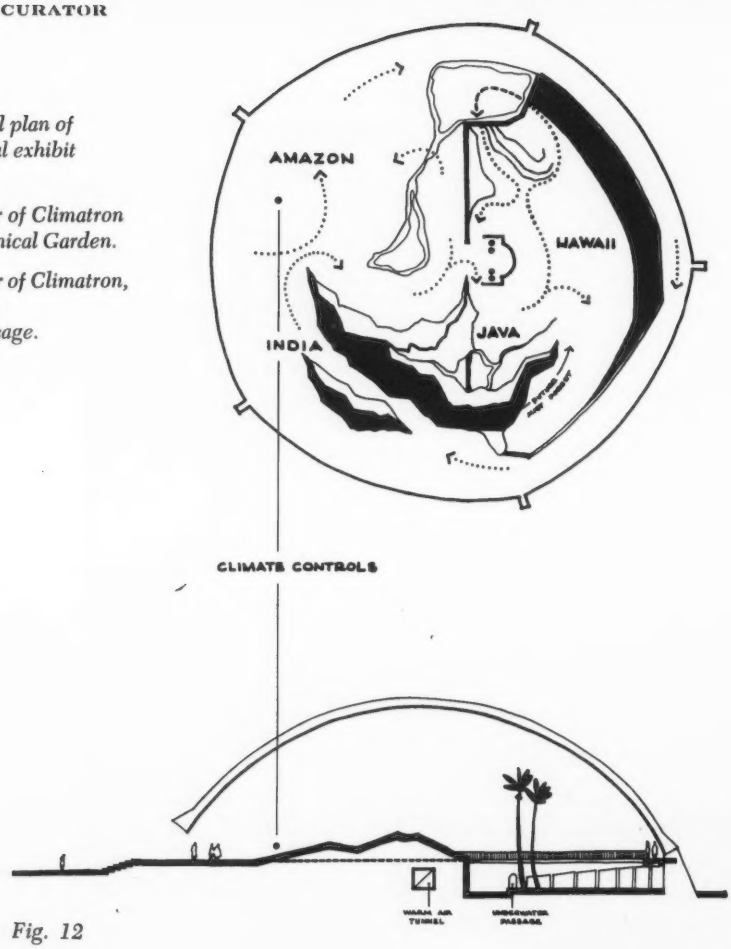


Fig. 12

that we encounter the very highest need for unencumbered flexibility. It is impossible to foresee either the physical dimensions or the social importance of the paraphernalia and products that may be developed in any field of the pure or applied sciences within an extremely short span of years. From a small laboratory experiment major industries and giant equipment may evolve within a decade. The architectural requirements for the public demonstrations of these developments are entirely unpredictable, except to the extent that the expectation of the unexpected has become axiomatic. The vast, unobstructed expanse of the Palazzo delle Esposizioni of Turin would seem the finest resolution to date for the problems of protean uses of space, which do not merely call for maximum freedom from immovable obstacles,

but also require complete emancipation from imperious elements of interior decor that would defeat any plan to fit the style of each exposition to its own particular purpose and content.

A comparison between the design of a theater and that of an exhibition hall is not without interest. In the playhouse all permanent architectural embellishments end at the proscenium arch. The space behind is structurally unadorned for the free exercise of the state designer's art in changing pageants. It would be quite unthinkable to have the style of the auditorium extend onto the stage, so that "Aida," "Carmen," and "Madame Butterfly" might all have to be performed among the columns and pilasters of theatrical baroque. But in the museum there is no separation between stage and parquet. Spectacle and spectators are completely intermingled, and it is not unfair to say that the main entrance to the museum is its proscenium arch. To the extent that flexibility is a desideratum, the architect's responsibility towards museum interiors is therefore simply to provide space for the exhibition designer's use, with maximum freedom from physical and esthetic impediments.

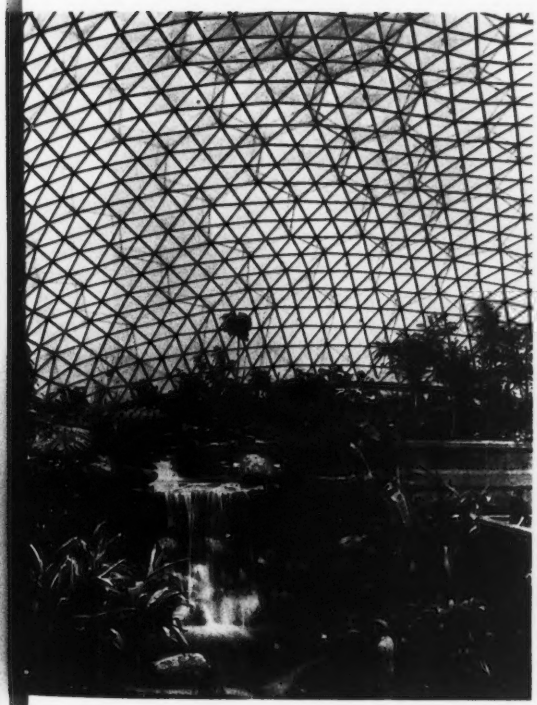


Fig. 13

Fig. 14

Fig. 15

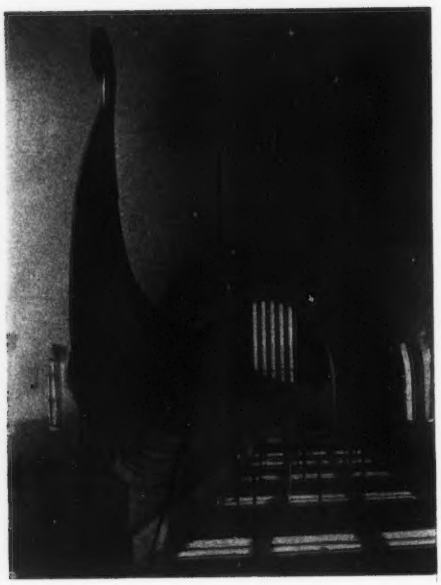


Fig. 16

In natural history museums the subjects and methods of exhibition may change more slowly than they tend to do in the museums of the exact sciences and their technologies, but the rate of change is still fast enough to make the durability of premises a perplexing dilemma within the span of a lifetime. To an outsider, looking in, it might seem as though the museums of art could enjoy the benefits of certain stable features of many of the objects they collect, although certainly not of all. For such a person it might seem conceivable that a gallery for the display of paintings could be so brilliantly designed that it would never lose its usefulness or the timeliness of its appearance. But this must be for others to speak of, with real knowledge of the needs of art museums.

Finally we come to institutions blessed with the knowledge that it will always be their task to continue to display the same objects that they show today. Historical houses fall into this category, but these do not concern us here, since their architecture is an already given feature of the specimen itself and not a problem of its shelter. But, as an example actually pertinent to our discussion, we may consider the Viking Ship Museum at Oslo. These ships were originally buried with the chiefs who owned them and sailed them. When the ships are disinterred in the cause of historical and archeological research, the museum designed to hold them forever after will, in the eyes of the perceiver, unavoidably acquire some of the hallowed qualities of a sarcophagus. This preconditioned attitude of the visitors can be used to great advantage to endow a building of unusual permanence with a sense of solemnity and with a closeness and specificity of esthetic harmony between contents and architectural container, which would involve an unpardonable restriction of flexibility in museums of more changeable import and intent.

Let us hope that the museums of the future will differ as much from one another as from the museums of today, and that in their differences they will explore and exploit all the architectural possibilities that lie between the temporary shelter of a geodesic dome for rapidly changing needs and the solid, ceremonial forms of a Pantheon for objects sacred to the history of a people or a cause. Among the many solutions that may lie within this broad range of possibilities, probably the most exciting one already suggested today is that of the proposed new museum of natural history for the University of Mexico described by Alejandro Caso elsewhere in this issue of CURATOR.

Fig. 15. General view of the Viking Ship Museum, Oslo, Norway.

Fig. 16. Views from opposite ends of same ship in the Viking Ship Museum.

All About "No Doubt About It" The TV Panel Quiz Program of the Milwaukee Public Museum

LEON W. WEISSGERBER, TELEVISION PRODUCER
MILWAUKEE PUBLIC MUSEUM

"Well, it's not a very big bone, so it can't be from a very big animal—but, then, it's not very small either, so it can't be from a very small animal."

This process we refer to as "out-loud" thinking on "No Doubt About It," a television program for teen-agers produced by the Milwaukee Public Museum. As indicated, in many instances there is a great deal of doubt about the objects we show, but we like it that way. We try to keep our teen-age panel of young scientists looking, thinking, and even guessing, if necessary.

For some time the Milwaukee Public Museum had been aware of a need for contact with the high school population of the city. Our Education Division handles a full schedule servicing the elementary school children up to the eighth grade with programs and guided tours. Various divisions of the Museum employ university student aides, and our curators are constantly asked by other university students for aid with their various scholastic problems. Our association with high school students until 1960 was negligible. We were looking for a way to close the gap.

In previous years Dr. Stephan F. Borhegyi, the Director, had appeared as a guest expert on educational, television, quiz-panel shows in the United States and Canada, such as "What in the World" sponsored by the University Museum, University of Pennsylvania, and "What Is It" put on by the Royal Ontario Museum. On these programs a variety of museum specimens were placed before a panel of experts for identification. The experts identified the objects and rounded out the program by telling interesting facts

about them. Dr. Borhegyi suggested that we explore the possibility of producing a teen-age program designed to operate in a similar way.[1] The idea seemed good, and, when the writer attended the WMVS Television Seminar at the Milwaukee Institute of Technology, the format of the program was developed.

Next we approached the Milwaukee public and parochial school systems with our plan. The educators enthusiastically endorsed it but insisted that there be no competition between schools or students. We agreed to such a restriction and talked with Mr. Richard Wenzel, the public school coordinator, who arranged a meeting with students selected as outstanding scholars by their science teachers. Meetings were also arranged with science students of parochial schools. The program was explained to the teen-agers, who expressed interest in trying it.

For our own peace of mind, we mailed a form letter as a reminder to each student about a week before his or her scheduled appearance, for we were constantly plagued with the fear of going on the air with one panel member—or possibly none! This fear was never realized. We found our teen-agers very eager to cooperate. If they could not appear, they arranged for substitutes. We seldom had a panel that numbered fewer than four.

Now back to the "out-loud" thinking that opened this article. Our panel members were able to identify correctly the "not-very-big" and "not-very-small" object; here is the way they approached the problem.

> STUDENT: It's probably not a mammal.
>
> MODERATOR: What gives you that impression?
>
> STUDENT: The shape of the teeth—they seem to be rounded and flat.
>
> MODERATOR: An excellent observation. You have just ruled out the world of mammals.
>
> STUDENT: Must be a cold-blooded animal. I think it's a fish.
>
> MODERATOR: Right. Now, what does he feed on? The shape of the teeth should be a clue.
>
> STUDENT: Predatory fish usually have sharp teeth. I would say this one is a bottom feeder eating small fish and plants.
>
> MODERATOR: I'll accept that answer as a proper identification. Specifically, we are looking at the jaw bone of a fresh-water drum, commonly called a "sheepshead."

Briefly, such is the way our show operates. The collective deduction of our panel members is usually rewarded with a correct identification.

The next object may be shown in its entirety. It might be a Colonial apple peeler, a hatchel or flax comb, or a Sioux Indian scalp lock. Often we prepare special slides that attempt to mask the identity of a relatively

[1] For other television programs produced by the Milwaukee Public Museum, see an article by Robert E. Dierbeck, former Television Coordinator of the Museum, "Television and the Museum," CURATOR, vol. 1, no. 2, Spring, 1958, pp. 34–49.

common object. We stumped our panel with a bottom-up view of a Victorian pressing iron. Consternation showed on four teen-age faces as the actual object was placed before them. We discussed the historical development of this household item in the United States and some of the weird forms it assumed in other areas, such as China.

We found it of educational value to show, either as a "clue" or follow-up, short film sequences or slides of some of the specimens identified on the program, particularly the animal world in action. This makes "No Doubt About It" distinctive from all other similar museum quiz shows. Our vast film library has placed unlimited footage at our disposal, giving our program a broader scope.

There are problems inherent in this type of panel show. The most serious is a panel that is not vocal or that develops stage fright and says nothing. To prepare the student for his first television experience, a "tip-guide" was mailed to him at his home. This guide listed hints that aided the student in developing topics during the show. For example, it was suggested that the student tell the viewing audience what the object was made of—bone, stone, wood, or metal—the color of the object, and whether it was man-made, as it occurred in the natural state, or of animal or insect construction. Clues as to the identification of birds and animals were also given. This approach helped to "start" the student and usually gave the viewing audience a clearer idea of color and size. Many hours were spent in the storeroom of the Museum in the collecting of material. If an object seemed to be usable, it was taken to the curator of the respective department, with the question "what is this?" The information from the various curators was amplified with library research. It was next to impossible to anticipate questions that would be asked by the panel. Certainly it was permissible to say, "I don't know," but too many of these negative responses could ruin the entire show. The moderator was expected to know most of the answers, but we must admit there were times when he was caught short.

On the program each item was introduced to the viewing audience by an off-camera announcer. Not all of the items were identified for the audience. Sometimes the audience was asked to guess, with the panel, while the show was in process. At the close of each program, we feature a "mystery object" and ask our viewing audience to identify it by sending their observations on a postcard to the Museum. The viewer submitting the first correct identification is awarded a year's subscription to the Museum's magazine *Lore*. We place the "mystery object" on display in a special exhibit in the concourse of the Museum. Viewers are invited to come in and take a closer look before submitting their identification.

Christmas and Easter vacations gave us the opportunity to invite persons especially interested in the Museum to try their luck on "No Doubt About

It." Our Christmas program featured a panel composed of four wives of The Friends of the Museum, Incorporated. At another session male members of the same group were represented on the program.

Production devices added a great deal to the brightness of the show, and, whenever possible, if the subject matter was of sufficient interest, film was used as a supplement. In some instances live animals were used, and they always brought an enthusiastic reaction from the panel members. The sounds of animals and birds were also used whenever possible. A good example was the use of an Indian flageolet. A slide of an Indian playing a flageolet was accompanied with a recording of the instrument in use. Slides, live animals, and music are not always available, but, when they are, they add interest and variety to the production.

Recently the Milwaukee Public Museum Television Committee agreed that some type of award for the participating youngsters should be presented, connected in some way with the Museum. We are presenting our panel members with museum reproductions readily available at moderate costs.

Our Museum program "No Doubt About It" will again be put on the air in the fall of 1961 and in 1962. We anticipate additional features such as historical points of interest and scenic beauty in our state, items of current interest (the sturgeon season, the duck season, or the purchase of new animals for the zoo or specimens for the Museum), and slides and films of the above-mentioned subjects. When our supply of suitable material is depleted, we plan to ask other museums for short-term loans of specimens. We also plan to broaden the service of our program by inviting teen-agers from outlying districts to participate.[2]

[2] In addition to the participation of the Milwaukee school systems on "No Doubt About It," we plan to include local scientific and specialized organizations such as the Wisconsin Archaeological Society, the Nature Club of Milwaukee, the Astronomical Society, and the Garden Club of Wisconsin.

Salvaging Fossils by Jet

GILBERT F. STUCKER

THE AMERICAN MUSEUM OF NATURAL HISTORY

The pet frustration of paleontologists—barring administration, exhibition, and legal impediments to collecting—is rock. It is the primary obstacle that stands between them and their realization of the past. Hence every effort is made to dispose of it and still retain its fossil content intact.

Traditionally, this was accomplished by Bunyanesque characters wielding sledges and chisels, crooked awls, and shellac pots. But the aim and scope of paleontology have changed since the early days. As understanding of the prehistoric world has grown, increasing attention has been focused on the details of individual fossil forms. This has brought a demand for more exacting laboratory preparation, with the purpose of inducing a higher yield of information per specimen—a growing number of which are small, fragile, and preserve considerable complexity of character.

If the laboratory is to keep pace with the research rooms, new tools and new techniques must constantly be sought.

Through the efforts of the Chairman of the Department of Vertebrate Paleontology, Dr. Edwin H. Colbert, a significant step in this direction was taken recently at The American Museum of Natural History in the acquisition of an Industrial Airbrasive Unit.

Interest in the unit had originally been stimulated by the use that was made of this type of machine at the Museum of Comparative Zoölogy at Harvard College. Paleontologists there had found the similar Airdent admirably adapted for the removal of the matrix from fossils.

The Airbrasive machine is a product of the S. S. White Industrial Division of New York. It is a precision instrument incorporating ideas conceived by Dr. Robert B. Black and is designed for a variety of commercial uses, among which is the etching of hard plastics, steel, and glass, the shaping of quartz crystals, and the cutting of germanium. As the name implies, it performs its task through abrasion, in the manner of a sand-blast.

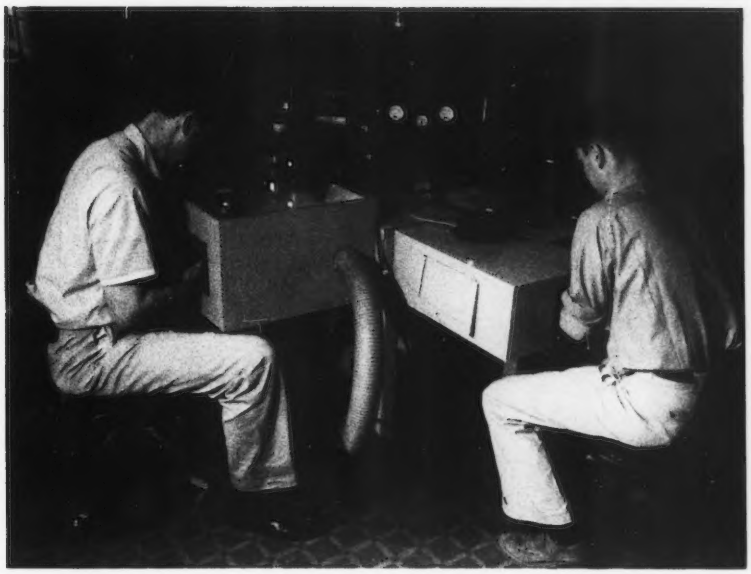


Fig. 1

Two models are manufactured. Ours is the dual-control unit, equipped in duplicate, which permits two operators to work it simultaneously.

Reduced to its simplest terms, it is a device for suspending minute abrasive particles in a stream of fast-moving gas and delivering them at a given point with sufficient impact to eradicate normally hard matter.

The gas is compressed carbon dioxide fed into the machine under controlled pressure from a metal cylinder. The abrasives range from a powdered metallic oxide to sodium bicarbonate which are added, as needed, to twin hoppers inside the unit. These hoppers are mounted over vibrators which keep the abrasive powder in constant agitation during operation, causing the particles to sift down through a perforated base into a mixing compartment beneath. The rate of vibration regulates the flow of abrasive into the lower chamber. There the particles are kineticized and,

Fig. 1. The Airbrasive complex. Inside the Airbrasive unit itself (center), compressed carbon dioxide and abrasive crystals unite into an effective cutting force. Conveyed to the two work compartments, their combined action gently relieves fragile fossils of encumbering rock.

Fig. 2

embodied in the gas stream, conveyed through elastic tubing to the nozzle head.

The entire complex—machine, gas, and abrasive—culminates, at this point, in a tungsten carbide nozzle with a 0.018-inch bore. Through this tiny aperture the abrasive is blasted forth at 1100 feet per second, to reach its point of impact and produce its effect.

A foot switch triggers the mechanism, activating the jet stream. All that it requires is a hard substance to work against. The harder the substance, the greater the cutting action. Against soft materials that absorb the impact, it is ineffectual.

When the machine is readied for the job, several considerations present themselves. What is the object of the work to be done? Is the intention to remove matrix, rough out bone, explore, or delineate delicate structure? What is the nature of the matrix? Of the bone?

Fig. 2. The Airbrasive hand piece is writing a new chapter in fossil preparation. Blasted from its nozzle tip, countless abrasive particles spray the rock. In the hands of Martin Cassidy, it aided in uncovering this specimen of a fossil fish.

Choosing the right abrasive is essential. For bulk removal of rock, especially of a refractory kind, or for very fast cutting, the manufacturer's No. 3 powder is used. This is a 50-micron[1] aluminum oxide; that is, it is milled to a particle size 50 microns in diameter, making it the coarsest grade currently available. It has a regrettable tendency to clog the tiny hopper holes, and for this reason the 27-micron aluminum oxide is used, where possible, in place of it. Listed as No. 1 powder, this allows greater latitude of application but is particularly effective on medium-dense materials. No. 2 powder is a calcium magnesium carbonate preparation employing a gentle touch for closing in on bone, working delicate areas, or cleaning off the last vestiges of matrix or mineral film. Originally developed by the S. S. White Dental Division for cleaning teeth, it does well in the preparation of paper-thin bone. Should the *tissue*-thin variety be encountered, the No. 4 powder (sodium bicarbonate) might come in handy.

Having settled the matter of the correct type of abrasive, one has the question of the correct quantity. Too much cutting agent at the nozzle head can spell the difference between bone uncovered and bone destroyed. The turn of a dial decides the difference. During normal operation about 10 grams a minute pass through the lines.

Still another factor to consider is the force with which the cutting particles are brought to bear against an object. This is determined by gas pressure, which is generally set at 100 (psi) pounds per square inch. For delicate work it can be reduced to a minimum of 30 psi at the cylinder head.

At the business end of the machine is a brace of blast nozzles made of sintered tungsten carbide to resist wear. These are the gadgets that deal the punches. Each cuts its respective jet stream down to the size of its particular bore.

These "nozzle tips," as they are termed, come in two types: one has a round bore 0.018 inches in diameter for the everyday jobs; the other, a rectangular opening that measures 0.006 by 0.060 inches for special duty involving precision cutting. They are joined to the hand pieces by a ball-and-socket joint, which permits the tips to rotate freely and vastly increases their usefulness.

TECHNIQUE

For cutting in depth, an incising action is obtained when the nozzle tip is held close and shuttled back and forth. The closer the tip, the more trenchant the cut.

For exploratory work, removing thin layers of matrix from wide areas, or

[1] One micron equals one-millionth of a meter.

Fig. 3

Fig. 4

cleaning up smooth-surfaced bone, the nozzle is held at a distance, which permits the abrading crystals to form a spray. With a sweeping motion the nozzle is played over the surface to be worked, the tip slightly angled. Maximum penetration is attained at the center of impact.

When extremely fragile material is engaged, it is often advisable not to center the blast on the object. Rather, it should be directed so that only the peripheral particles come in contact with the specimen.

Throughout the operation, the jet should be kept in motion so that the powder works against the matrix and not against itself.

Its mission accomplished, the spent abrasive becomes a waste product and therefore a problem. Although presumably free of elements toxic to the human system, excessive amounts should not be breathed. Certainly it should be kept from microscopes and other delicate equipment.

What to do with it? The matter was taken up by Dr. Bobb Schaeffer and Mr. Walter Sorensen of the Department of Vertebrate Paleontology. Together they designed two wooden work chambers, conveniently compact but of ample size to accommodate a wide range of specimens. Both measure twenty-six and one-half inches long by nineteen and one-half inches wide. In depth they vary from twelve inches to eight inches. They are bolted to a work table which incorporates them into a unified whole comprising Airbrasive machine, microscopes, gas cylinder, and the exhaust system. The height had to be adjusted so that the microscopes could be operated at eye level from their tops and still afford knee room beneath.

A hinged door at one end receives the specimen, which can be manipulated inside the box through paired arm holes. These are fitted with elastic sleeves to prevent abrasive seepage. On the opposite side, rubber tubing snakes into the compartment and conducts the cutting powder to the nozzle tip. Expelled, the powder is suctioned out of the box by a vacuum motor and conveyed through a flexible conduit to a large dust receptacle under the table. Plate glass seals off the top, which can be removed at will for cleaning or for the introduction of specimens too large for the side door.

In time, the continuing attrition of abrading crystals frosts the glass,

Fig. 3. The skeleton of a small fossil reptile as it was brought to the Museum, before being given the Airbrasive treatment. Preserved in hard shale of Triassic age, it was discovered by Alfred Siefker and Michael Bandrowski in the celebrated Granton Quarry of New Jersey.

Fig. 4. Exposed by the abrading jet in three months' time, this earliest-known vertebrate avian, new to science, exhibits many unusual osteologic features.

Fig. 5

especially when the 50-micron powder is used. To obviate this, a solid panel of masonite or plywood can be substituted, with a small window opened into it. Cover glasses for the standard lantern slide can be inserted in the opening. They are of a convenient size to work through and are much easier to renew than the larger panes.

Tying this all together is the human element. As with any tool, the effectiveness of the Airbrasive is in great measure a translation of the skill of the operator and his coordination of eye, hand, and foot.

The unit has its shortcomings, of course, as it is a sensitive piece of equipment constructed to close tolerances. The rubber pinch valves are continually giving out. The rubber tubing perforates. Steel fittings are abraded through. Terminal blasting subjects the nozzle tips to vicious wear which requires frequent replacement.

On some matrixes, particularly those with varying densities, the machine will not work well. Such matrixes are abraded unevenly, and pits and undercuts form. Sandstones and sandy siltstones exemplify this difficulty. The abrasive works around the grains, infiltrating the interstices. It penetrates below the visible surface, working unseen. Thus, bone may sustain damage without the operator's being aware of it.

Still, for us, there is no question as to the worth of the Airbrasive. As the microscope has extended our visual capacities, so this machine has empowered our hands, endowing them with a facility for dealing with struc-

Fig. 6

Fig. 5. A fossil skull from Brazil embedded in a hard calcite and hematite matrix.

Fig. 6. The fossil skull (palatal view) of a cynodont reptile after removal by the Airbrasive technique from the same matrix as shown in Figure 5. Aluminum oxide powder No. 3 was the principal abrasive used. Detailing of teeth was done with calcium magnesium carbonate powder No. 2.

tures beyond our ability a few months ago. It has, in fact, keyed us into that tantalizing world of the minute and the intricate that lay buried within range of our 'scopes for so long, but could not be revealed for lack of the proper tool.

It even works on the Triassic.

As every preparator knows, Triassic rock, among others, is not to be taken lightly. It is trouble enough that fossils come encased in rock. When that rock is Triassic, the trouble multiples. Fossils have only to be "extracted" from normal matrixes. From the Triassic, they must be "extricated."

A case in point is the significant collection of cynodont remains recently made in Brazil. Here we are faced with many new and rare forms that will some day shed much light on their particular "acre of time"—when, that is, we can get the rock out of the way.

The Airbrasive has been working on this problem for some time, but the nature of the matrix is such that progress is slow. The material is enclosed in, and invested with, a refractory mineral combination composed chiefly of calcite and hematite. This was deposited in a heavy layer around the bones by highly saturated waters and remained, upon evaporation, to cement the various osteologic elements together into hard, impenetrable masses. Subsequent pressures operated to compress the masses, embedding bone in bone, and thus adding to the preparator's "delight."

Preparation has concentrated on the skulls in the collection, three of which are currently "in the works." One finds no separation between specimen and matrix. Bone surface is badly checked and, in some places, completely lacking, with no underlying structure.

Cases such as this receive the "full" treatment, Airbrasivewise. That means a full head of gas (120 psi at the tank) and the coarse 50-micron powder.

Initially, this was a "surgical" operation, a matter of cutting the bone masses apart. With the nozzle tip held close, incisions were made, exploited into deep grooves, and eventually there was separation.

Cleaning up the separated pieces would normally have been done with soft abrasive. But with a cementing agent so stubborn, the coarse grades were kept in the hoppers. Only for detailing the finer structures, such as teeth, was the softer powder employed. A fine battery of these has been worked out on one skull.

The matrix that has responded most satisfactorily to this new method is the hard, black, uniformly dense shale from the celebrated Granton Quarry in the Triassic of New Jersey. Long noted for its fish fauna, it has recently produced some excellent reptile remains. One slab contained an almost complete, articulated skeleton of a gliding reptile—the first of its kind and the oldest known vertebrate avian. Fragile, it is about eight inches long and remarkably preserved. From start to finish it was prepared with the Airbrasive unit. The rock abraded particularly well. The bone was such that it could be thoroughly cleaned with but trifling damage from the blast. However, when the jet was retained an instant too long, the bone surface broke up and flaked away. Only in one place was the matrix too much for the machine—a pyritic patch embedding the right hand.

Three months were required for the job, a small fraction of the time necessary in other years. Indeed, it is almost certain that former methods could not have accomplished the task in any length of time. As the bones were small and delicate, the soft No. 2 abrasive was used exclusively, with the gas pressure reduced through much of the operation. Most difficult was the delineation of the skull parts. A number of these were paper-thin laminations, translucent when held to the light. On the under side of the slab a window was cut to expose the ventral portions of skull and jaws.

In the light of its miraculous performances, the Airbrasive unit is certainly in paleontology to stay. Does this mean that the preparator is becoming obsolete, doomed, on his way out, to join the many forms on which he works into extinction? On the contrary, we think his salvation is at hand. If paleontology, in essence, can be considered a rescue operation into the past, the Airbrasive machine has, in a very real sense, rescued the preparator from the rescue operation.

IV/4 1961

Proposal for a Museum of Natural History for the National University of Mexico

ALEJANDRO CASO

The many fine cultural institutions of which Mexico City is justly proud do not, as yet, include a museum of natural history at all comparable with such museums in the other great capitals of the world. In the light of our country's great faith in public education this omission from our educational facilities seems all the more paradoxical. Conscious of the lack, and of the potential contribution to the life of our nation that a properly conceived and executed museum of natural history might make, the author, in association with Margarita Chavez de Caso and Jorge Stepanenko, undertook the preparation of plans and recommendations for the creation of a Museum of Natural History of the National University of Mexico.

In the development of our ideas we have been guided by the knowledge that museums must no longer be considered mere exhibits of good or strange collections but expositions devoted to the demonstration of ideas and scientific theories in order that the visitor will not only have opportunity to admire each of the objects shown, but will also obtain a new knowledge and a new understanding of what he sees. The museum will be "concerned with the interpretation of nature rather than with its mere presentation," trying to teach man to see nature as a whole, and to live within its framework.

The exhibition program has been planned with three main questions in mind: What is to be shown, to whom, and how?

The museum will not be of the universal kind. Cost would probably make such an ambition impossible, but this is not our reason for concentrating upon the natural history of Mexico. We have sought to give the exhibits a logical sequence and an aggregate unity, presenting, if not "the complete history of the universe, the earth and its inhabitants," then certainly that of a small part of the earth and its inhabitants; stress-

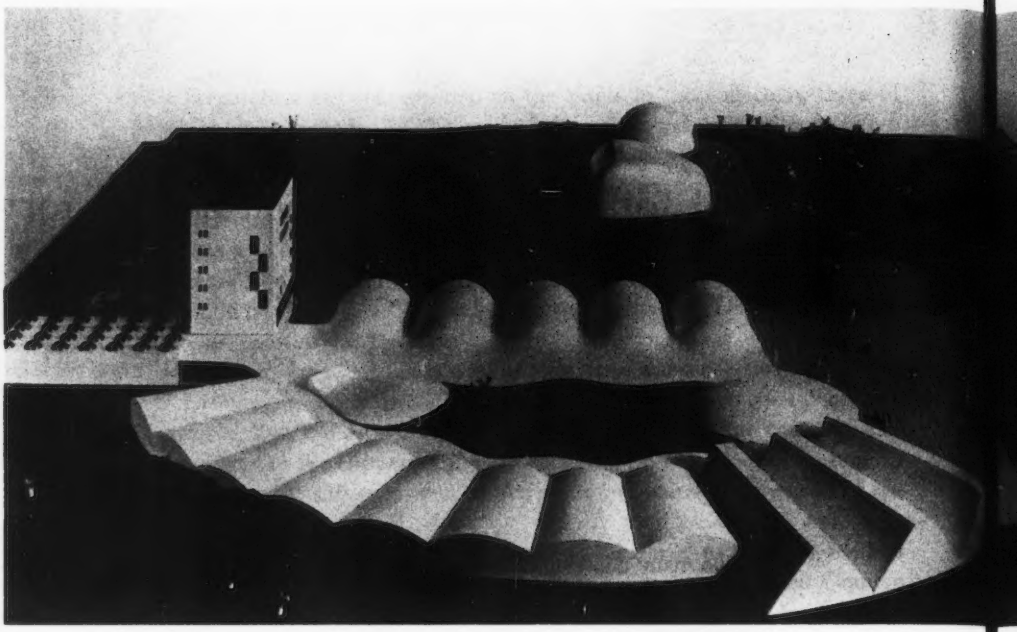


Fig. 1

ing their total relationships, the universal laws that rule them and, finally, the conservation of nature and man's direction of it to his advantage. We have focused mainly on the flora and fauna of the country, because Mexico already has a museum of geology and another of anthropology and we have not attempted to add to the functions of these except for noting the total relations which unite them. Thus the exhibition will be divided into three parts:

1. *Ecological Groups,* which will seek to give an idea of what the country is like, stressing the total relations between the habitats.
2. *Fundamental Principles,* in which we will attempt to explain universal laws that rule nature, and, as a conclusion, how the future existence of mankind will depend on better understanding of the world, and of man's best direction of his relationship with nature.
3. *Temporary Exhibits,* intended to complete the exhibition, specially in a universal aspect.

The museum will be intended for the general public. The exhibition will not be organized along the lines of the specialist, in systematic classi-

Fig. 1. Architectural model of proposed natural history museum for the University of Mexico.

fication or taxonomic groupings, but will seek, by more intuitive means, to "meet the needs of the farmer, the industrialist, the housewife, the teacher, the student and the child." The museum's aim will be for people to know their own country and its ecology; to make them understand nature and their own situation in their natural environment and vis-à-vis the rest of the world; and to learn how to preserve their country and use it wisely.

The following considerations on how the exhibition is going to be made constitute the skeleton over which the whole architectural project was built. The three different groups into which the exhibits have been divided cover distinct features, giving three particular forms of each group of exhibition halls that make up the body of the museum.

The first five halls—those given over to the ecological groups—seek, as we have already said, to draw the attention of the spectator towards the knowledge of his country. With this in view, we have selected the five most representative regions, reproducing them in such a way that the visitor will move into the environment in which the plants and animals live. Instead of merely seeing them as through a window, he will enter into and walk through a stretch of jungle, mountain terrain, desert, plateau, and sea bottom. In addition to the fauna, flora, geology, and lighting peculiar to each realm, temperature and humidity will be simulated as well as its characteristic smells and sounds. Through these means we hope to give a vivacity to each exhibit that will arouse the visitor's interest and effectively fix in his memory the knowledge and experience received. The dioramas in which the various landscapes are reproduced appear in the architectural design in the form of barrel-vaulted long domes terminated by spherical sections at both ends.

In these walk-in habitat groups we have sought to analyze the problems involved in ushering the visitor inside and through the exhibits and have modified the form and size of the halls to the curves of visibility and acoustics, both in regard to the form of the vaults and to the most effective distances for observation. The line of sight is interrupted by partitions made of natural elements such as rock, trees, and so on, which maintain the spectator's vision within an angle of incidence that does not deform the image painted on the cyclorama. As can be observed from Figure 4, there is a continual displacement of the circles in which the conditions of visibility will be optimum for the spectator and from which the form of the hall was derived. In reproducing the environment mere realism without interpretation has not been the aim; through lighting and color, as well as in the placement and attitudes of the animals, it will be sought to aid the visitor in seeing what is truly important. In addition, each hall will feature a vestibule which will serve as an introduction to what is to be seen within, with explanations of the diverse plants and animals shown in the diorama, mentioning their classification and some of their more im-

portant characteristics, as well as the locality and the interrelationship between the environment and the forms of life, thus giving the visitor an idea of the unity of nature and the reasons for the coexistence of the animals and the plants of the region illustrated.

Once a synthesis of the country has been presented, the subsequent halls will explain the fundamental principles that regulate animal and plant life on the globe and condition man's exterior world. These exhibits will seek to make understandable the environment which surrounds man and which has just been observed in the preceding halls.

As an example of the type of subjects we propose for these halls, we have chosen the principle of the evolution of the species. By means of a great spiral, ramified at one end, we shall try to represent a great genealogical tree and simultaneously give a suggestion of time. This great spiral would be suspended along the length of a hall, with each of the most characteristic examples of the different steps of evolution spotted with lights and placed in the proper space of time. As can be seen, an abstract type of museography has been chosen, because it has been considered the best way to express the general ideas to which these halls are devoted.

In these expositions of fundamental principles, we shall attempt to

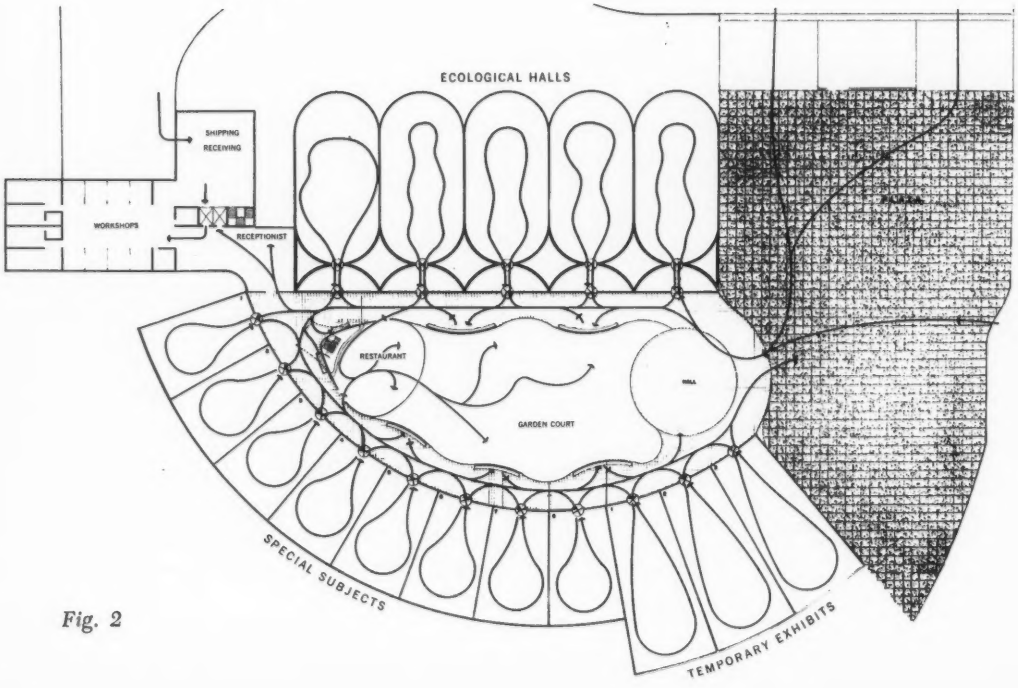


Fig. 2

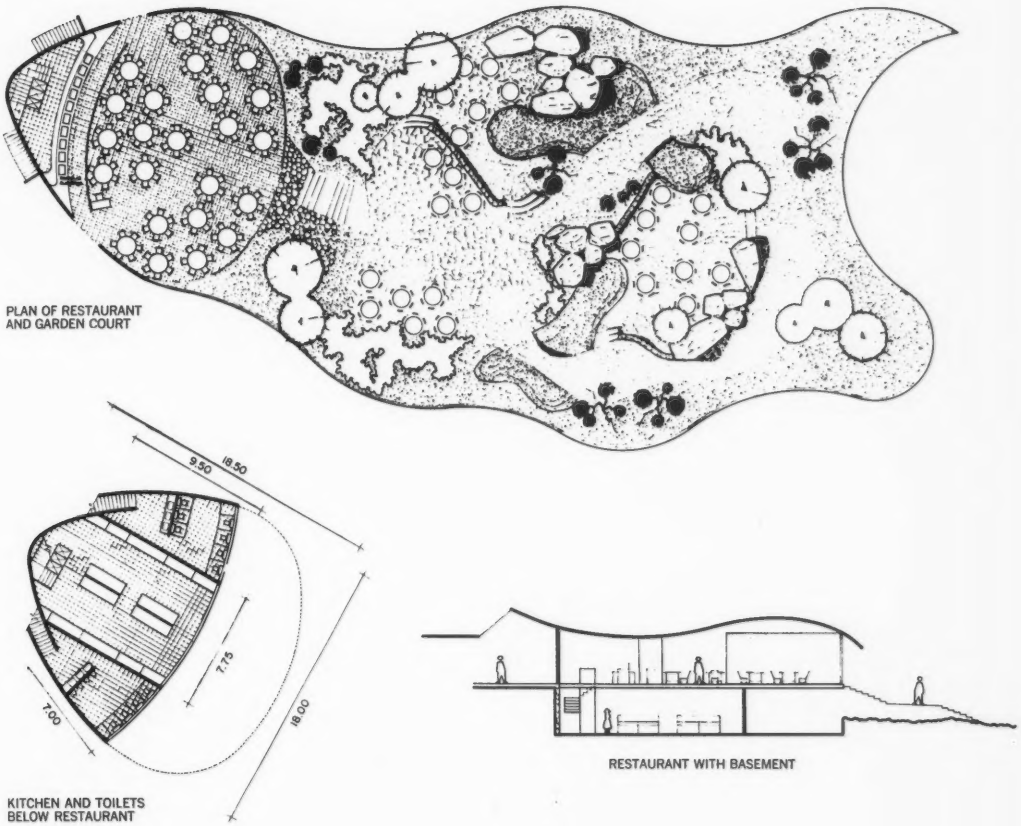


Fig. 3

eliminate from the visitor's mind any awareness of interior architecture in order to obtain an absolute freedom of expression and to concentrate the spectator's attention on what is exhibited. From the vaults of these halls, generally painted black, lighting arrangements will be employed to emphasize, differentiate, or attract attention; shock, repetition, and appeal to the viewer's imagination will be resorted to, making use of colors, sounds,

Fig. 2. General plan for the proposed museum of natural history of the University of Mexico.

Fig. 3. Plan of garden court with restaurant. Kitchen and toilets beneath the restaurant shown at the left, below. Dimensions given in meters.

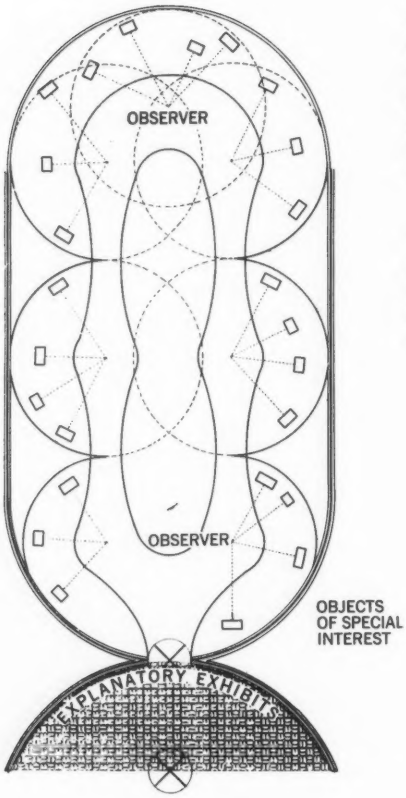


Fig. 4. Ground plan of a hall of ecology and introductory vestibule, with analysis of perspectives seen from various points of observation. Rectangles represent objects of particular interest.

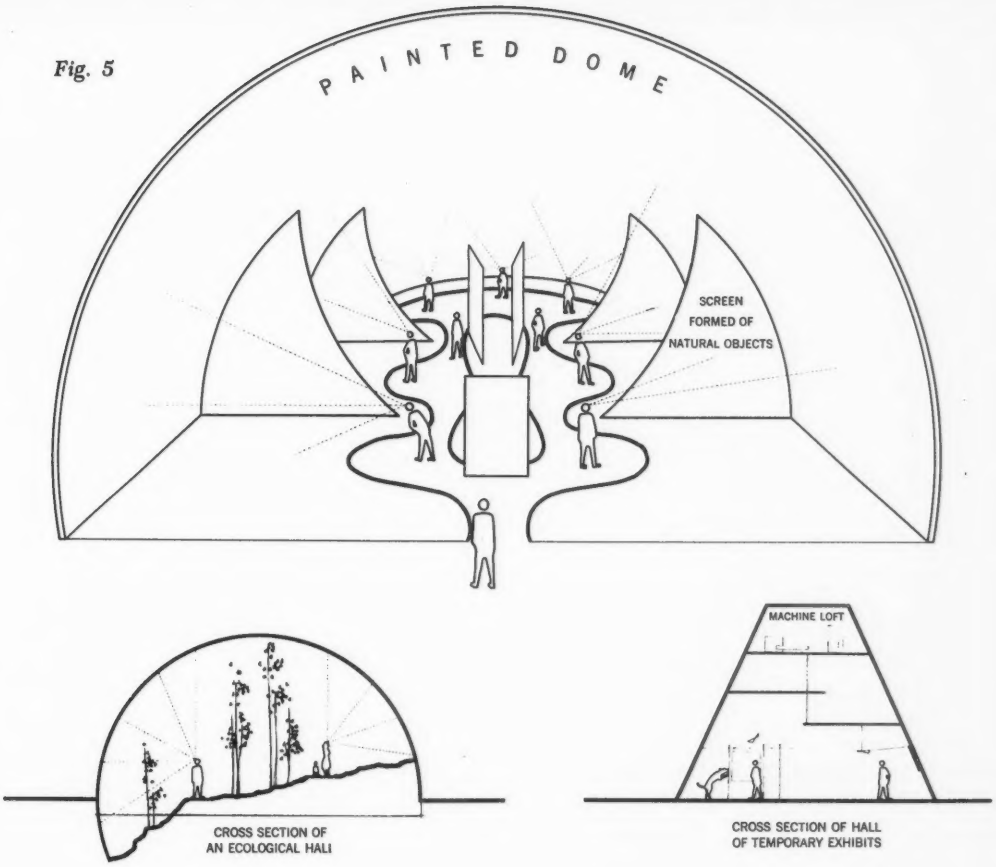
Fig. 5. Above and at left, below: Analysis of perspectives in a hall of ecology. At right, below: Cross section of a hall of temporary exhibits.

Fig. 4

music, and an adequate typography, to achieve the desired effects. The vaults of these halls will be arranged so as to form a fan allowing for the enlargement of the exhibition area towards the rear and grouping the entrances together in the general path of circulation. The last two halls in this group will be used to show the importance of natural resources in their utilization and for the preservation of the indispensable order and harmony of the world in which we live, and, lastly, to show how man can modify the nature of plants and animals to his benefit through the application of his knowledge of the laws of genetics.

The last group of halls will be dedicated to temporary exhibits which will complement the permanent exhibition. The first will be used to establish comparisons between the flora and fauna of Mexico and those of other regions of America and the world. In reproducing other environments and other habitat groups, we will rely on subconscious suggestions rather than realistic reproductions. The second will be a natural history

Fig. 5



center for children, dedicated to awakening a serious interest in the natural heritage of the country and fondness for the study of biology. The last will be devoted to themes which we might call special or timely, and which could be carried out with the purpose of renewing interest in the museum, leaving freedom for experimentation with the development of new museographic techniques. The pyramidal cross sections of these last three salons will seek to give the elasticity which museography requires when exhibits are to be changed constantly. As can be seen in Figure 5, the slanting walls have as their object to give a better angle of vision to what is exhibited on them, and also to give room for installations behind any panel placed vertically. On the other hand, by reducing the width of the upper part of the space and letting it reach a higher level than that of the rest of the exhibits, we are allowing space in which to place a mezzanine for special installations, winches, false ceilings, lights, and other equipment.

In developing this proposal it has been our aim to solve the pedagogical

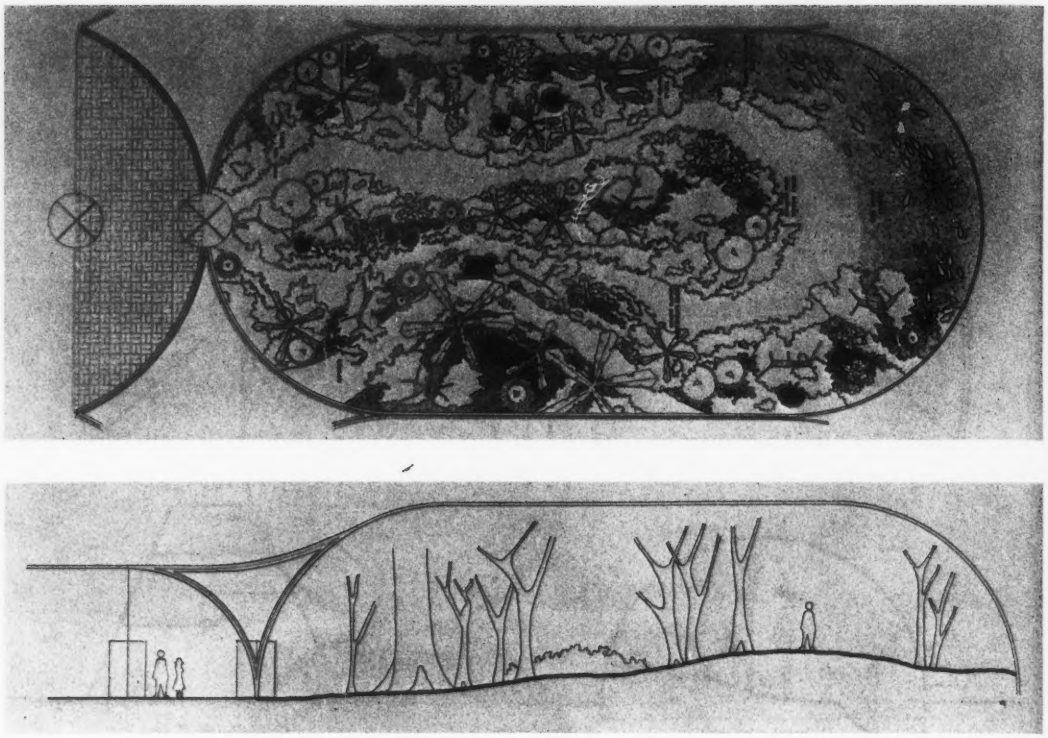
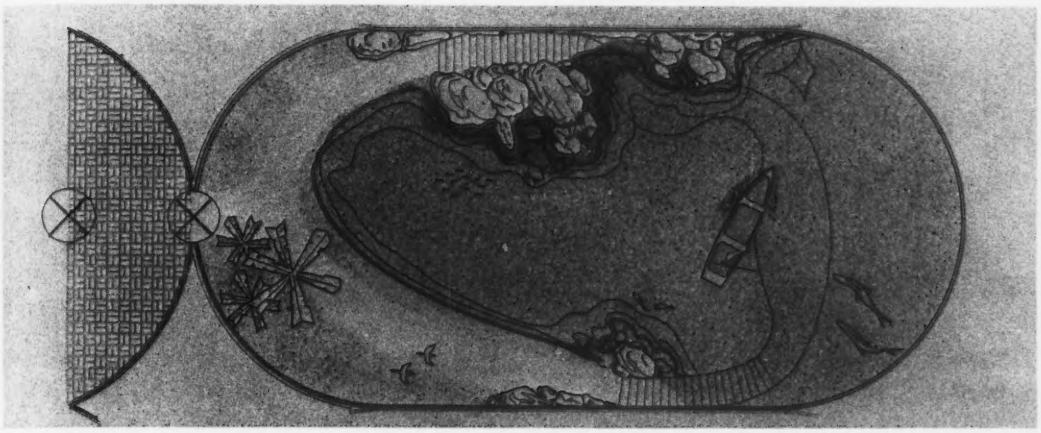


Fig. 6

aspects through architectural design, using sound systems and booklets only as complementary explanations of the exhibition.

In order to arrive at the most adequate distribution of exhibits, we have tried to analyze the best functioning pattern for a museum on a "human scale," taking into account the interest, the resistance, and the time available to the visitor. One day will suffice to make a complete visit that will permit the spectator to follow the logical sequence of development of the exhibition to the end.

There will be only one floor for the public, so that all of the exhibition halls, as well as the rest of the facilities, will lead off a central hall. By this arrangement the visitor will obtain a general picture of what he is going to visit from the moment he enters, and after covering each of the halls he will have an oportunity to rest in the areas reserved for this purpose to one side of the general circulation. Aside from the unity it gives to the museum this will permit all of the halls to be perfectly independent, with each one constituting a unit in theme as well as in distribution, giving the



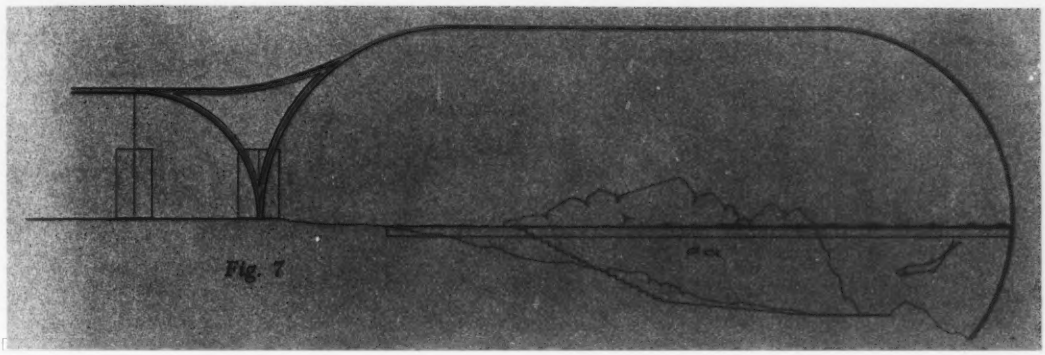
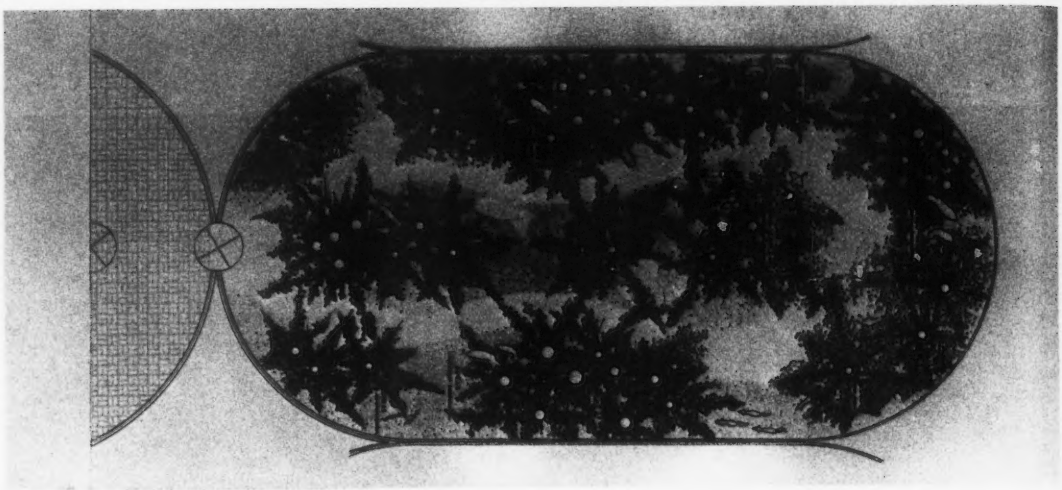


Fig. 7

exhibit enough order and flexibility so as to adapt itself to the interests of each visitor.

With the idea differentiating the distinct elements in regard to their functions, the museum proper has been made independent of the other sections of it. All of the administrative aspects have been grouped in a seven-story tower which will include the office of the Director, Department of Education, Storage for the Museum Collections with study cubicles, Management with services for employees, and the Administration proper. The ground floor, which juts out from the block of the tower, will be set aside for the Museographic Department, with workshops in which the

Fig. 6. Hall of jungle ecology. *Fig. 7. Hall of marine ecology.*



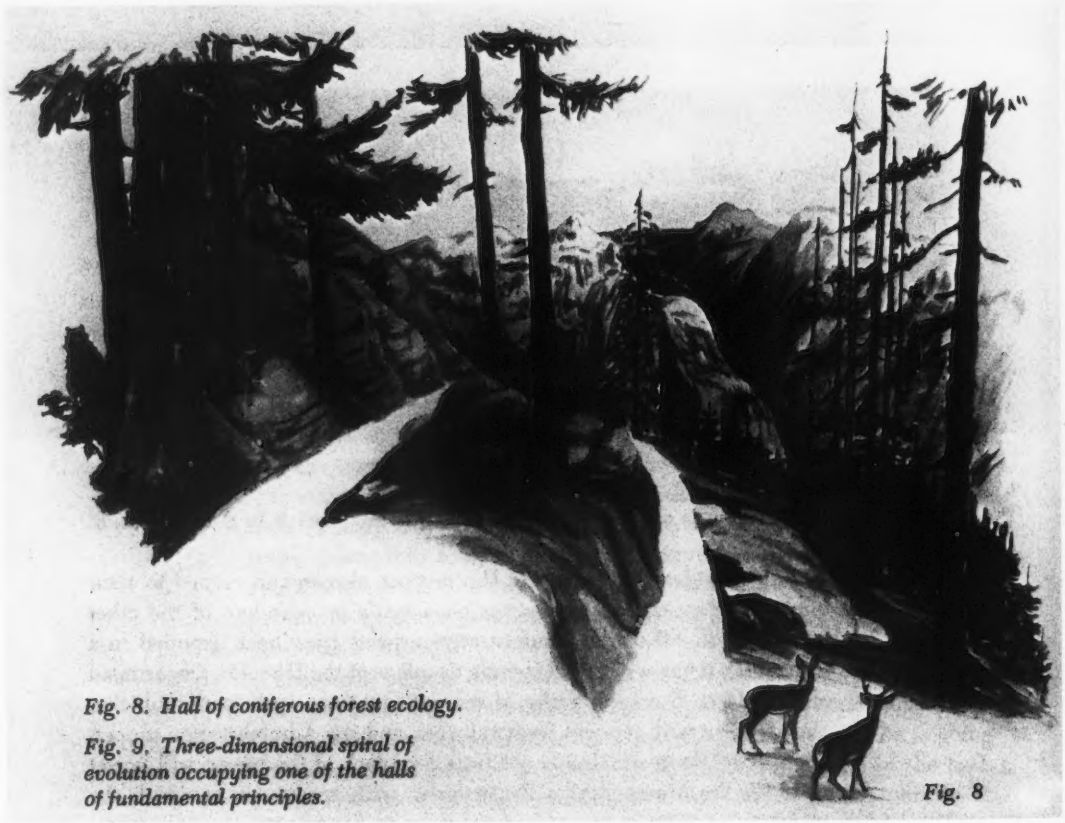
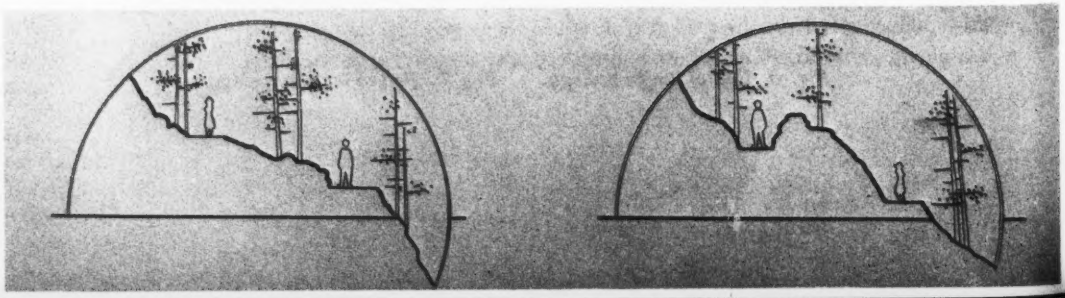


Fig. 8. Hall of coniferous forest ecology.

Fig. 9. Three-dimensional spiral of evolution occupying one of the halls of fundamental principles.

Fig. 8



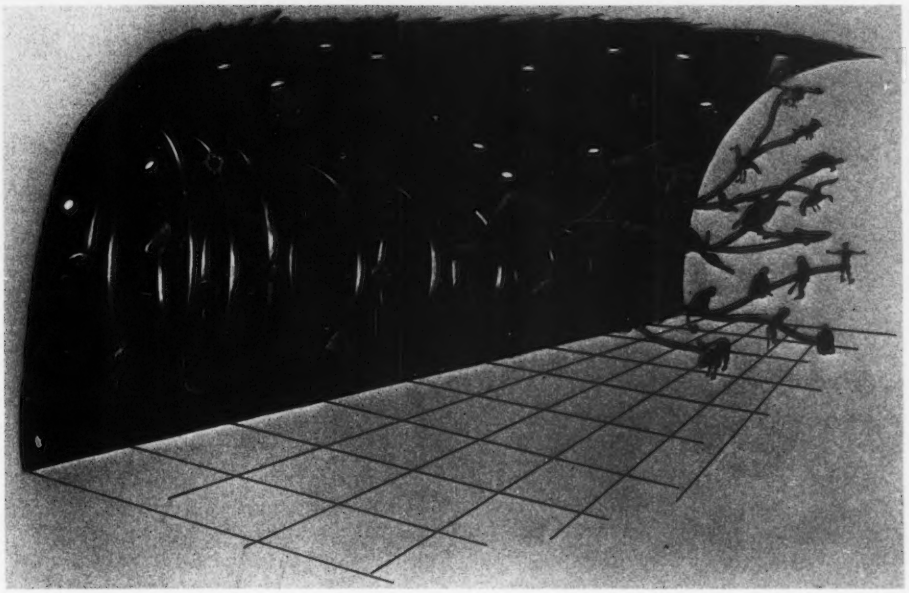


Fig. 9

preparation of exhibits will be done, and for storage. Very little space has been left for the functions of research, because these will remain separate in the Institute of Biology, located in the surrounding grounds.

Thus, broadly speaking, the museum will consist of an entrance vestibule, three different groups of exhibition halls, an interior garden, a restaurant with all other general services, and the administration tower with workshops. Forming units apart will be the auditorium and the planetarium.

The museum building will form part of the complex of the University in Mexico City, on ground surrounded by volcanic lava, which naturally influenced the general form of the project. Nevertheless it was the analysis of what was to be exhibited and how it was going to be exhibited that constituted the determining factor of the architectural program and of the resultant forms. It was the study of the museum's needs that has given the building its special stamp.

In our proposed museum the architecture has thus been adapted to a total pedagogical sequence of exhibition, to the objects to be exhibited, to the methods we consider best suited for their display, and to the needs of the people for whom the museum will be built.

The Career of Charles R. Knight

Charles R. Knight (1874–1953) was renowned for half a century as a superb portrayer of animals, living and extinct. His work, to be seen in various museums throughout North America, is a record of ancient animals and plants that in years to come, as in years past, will bring an appreciation of the life of long ago.

The career of Knight is a nice example of the fact that men make museums and museums make men. It was the artist who gave life to the dead bones, yet it was the museum with its resources of scholars, books, and collections that enabled the artist to interpret the past with the insight of research added to the skill of his hand. Knight was a fine artist, but

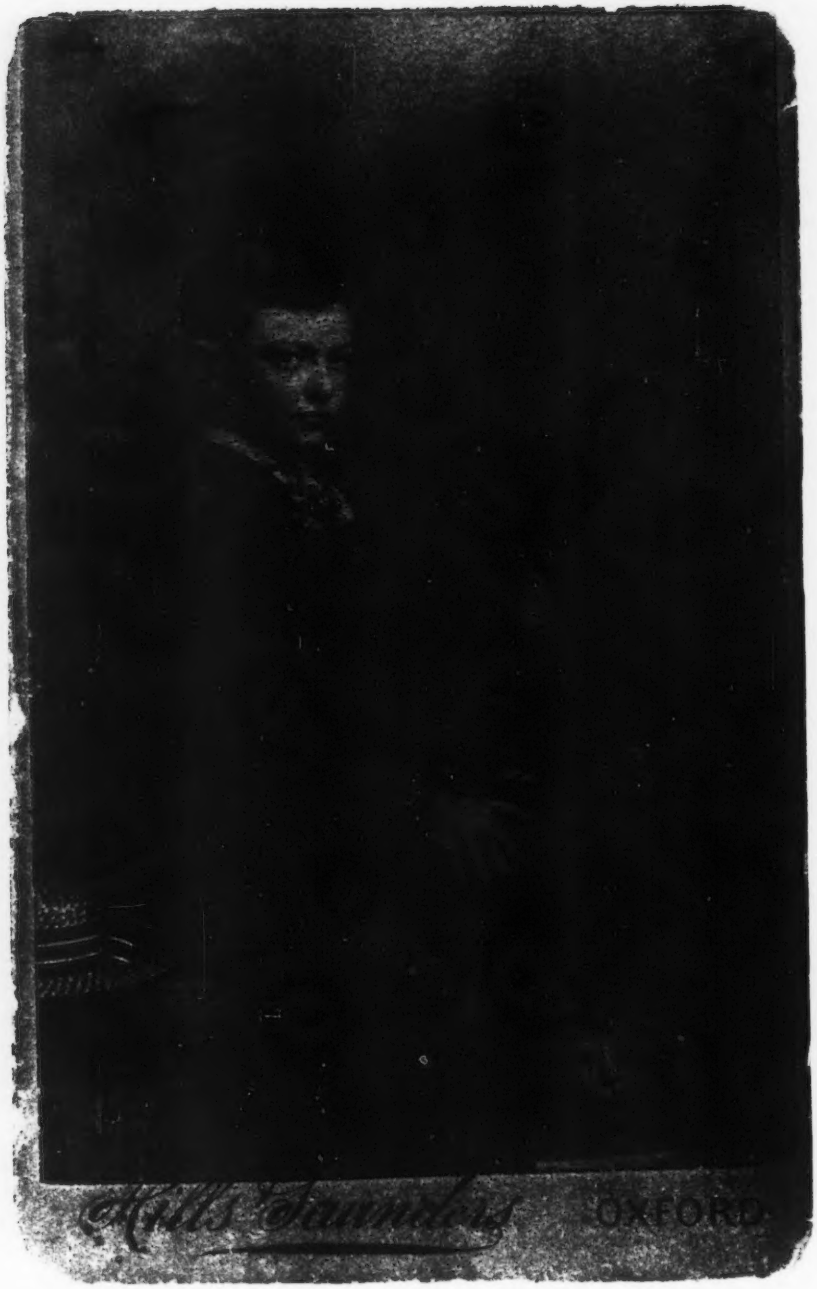


Fig. 1

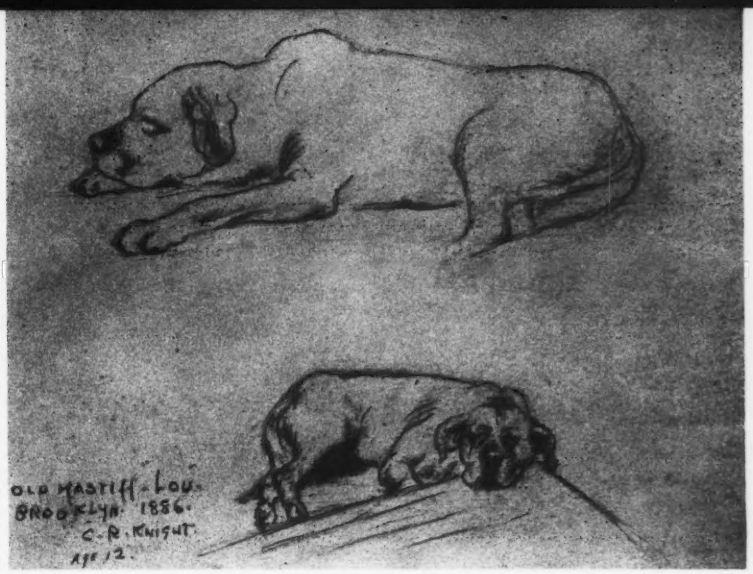


Fig. 2

without the environment of the museum he never would have attained the very special eminence that made him world famous. The museum had unexcelled collections and outstanding scientists to study them, but without Knight there would be missing those vignettes of past life that make inconsequential a hundred million years of geologic time.

Knight's ties were primarily with The American Museum of Natural History, where he began his unique career and where he spent much of his time through the years. To honor him the Museum, during the period January to June in 1961, devoted a special exhibit to his life and his work. Excerpts are presented on the following pages.

Two factors shaped Knight's life. He loved animals and he had an innate ability to draw. He made the sketch shown in Figure 2 when he was twelve years old.

Knight was a metropolitan New Yorker, by birth and life-long residence. He grew up in Brooklyn, and attended the Froebel Academy in that borough and the Brooklyn Collegiate and Polytechnic Institute. He subsequently studied at the Metropolitan Museum School of Art, the School of Design, the Architectural League, and the Art Students League, and worked under such masters as George de Forest Brush and Frank Dumond. In the early days of the present century he was a designer of stained glass windows and a free-lance magazine and book illustrator. His drawings of animals attracted the attention of zoologists and paleontologists, and while

Fig. 1. Photograph of Knight as a boy, with dog.

Fig. 2. Pencil sketch of two dogs.

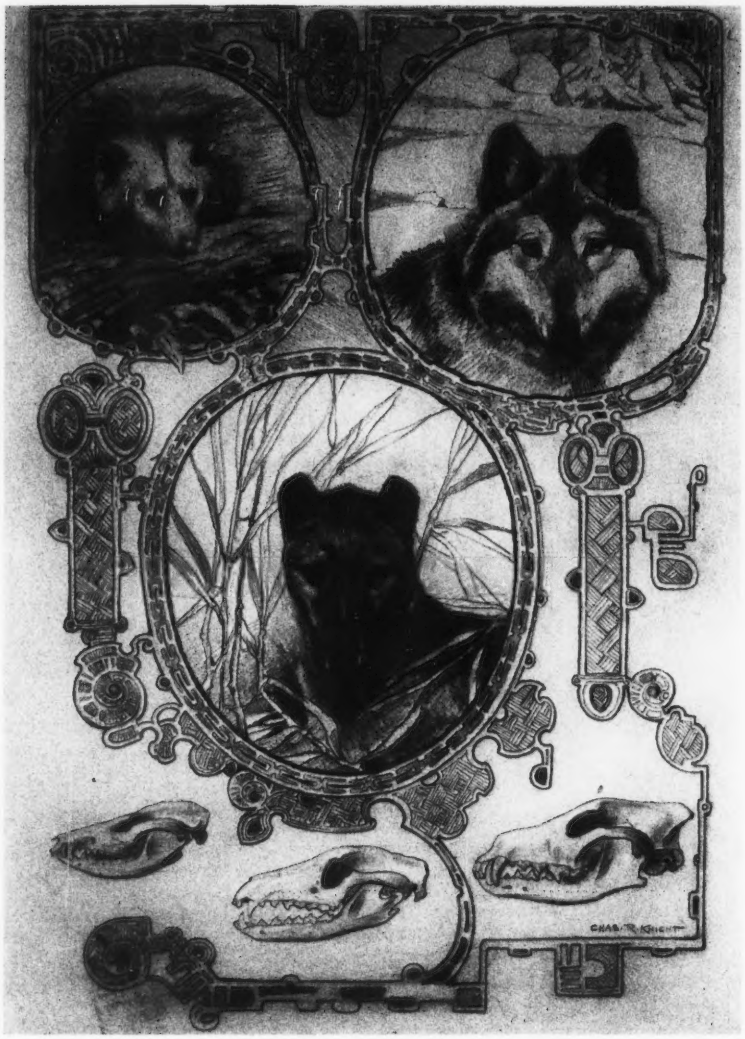


Fig. 3. Opossum, marsupial "wolf," and gray wolf.

still a very young man he began his work at The American Museum of Natural History.

Even before the beginning of his long association with The American Museum of Natural History, Knight had made some illustrations for the then ailing Edward Drinker Cope, a pioneer student of fossil vertebrates

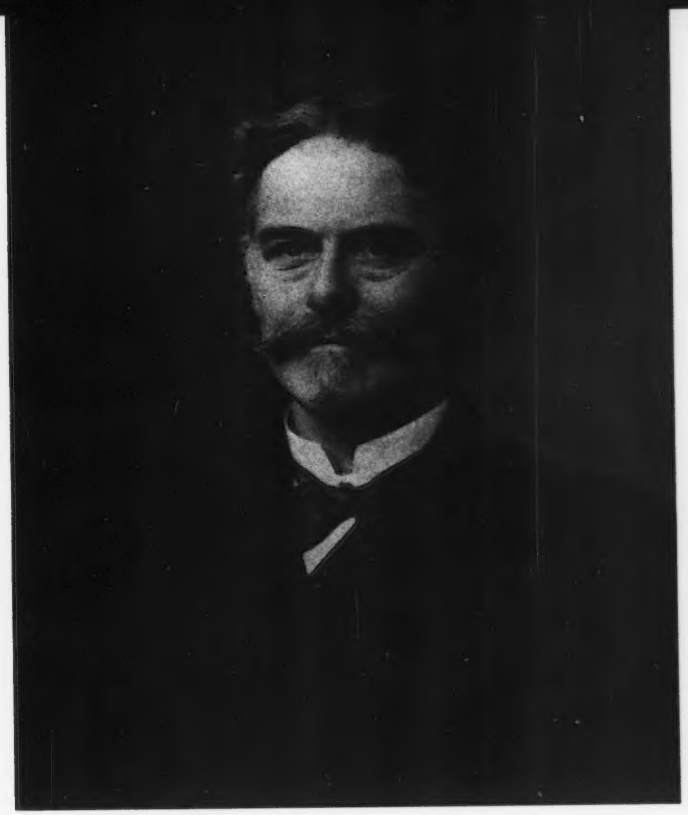


Fig. 4. Edward Drinker Cope.

Fig. 5. Self-portrait of Knight.

Fig. 6. Restoration of Elotherium.

in North America and one of the great men of American science.

From a manuscript autobiography, Knight gives the following account of his work with Cope.

"I was given a drawing table in the bay window (at Cope's house), and there every day for the ensuing two weeks I listened with rapt attention to the greatest conversationalist that ever graced the service of Paleontology.

Fig. 7. Henry Fairfield Osborn.

Fig. 8. William Diller Matthew.

Fig. 9. The duck-billed dinosaur.

Fig. 10. Diplodocus, *a gigantic sauropod dinosaur.*

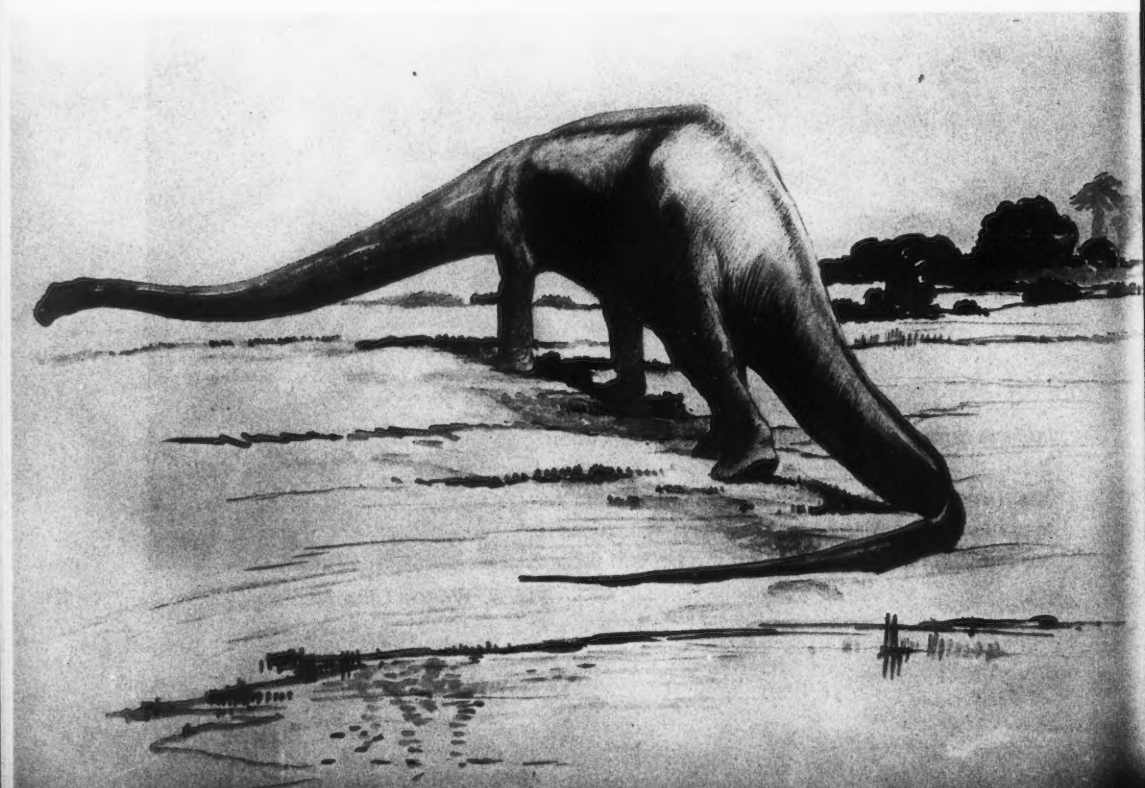


Fig. 11. Ichthyosaurus, *a marine reptile of Mesozoic times.*

Under the spell of his facile tongue, new vistas of life of the past opened before me in a way I had never dreamed of. Under his expert guidance I felt that I had stepped back into an ancient world—filled with all sorts of bizarre and curious things, and in imagination I could picture quite distinctly just what these mighty beasts looked like as they walked or swam in search of food."

"John Rowley [the Museum taxidermist] and I had become very good

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Fig. 12. Eohippus (*or* Hyracotherium), *an ancestral horse of Eocene times.*

Fig. 13. Equus scotti, *a Pleistocene horse of North America.*

Fig. 14. The American mastodon.

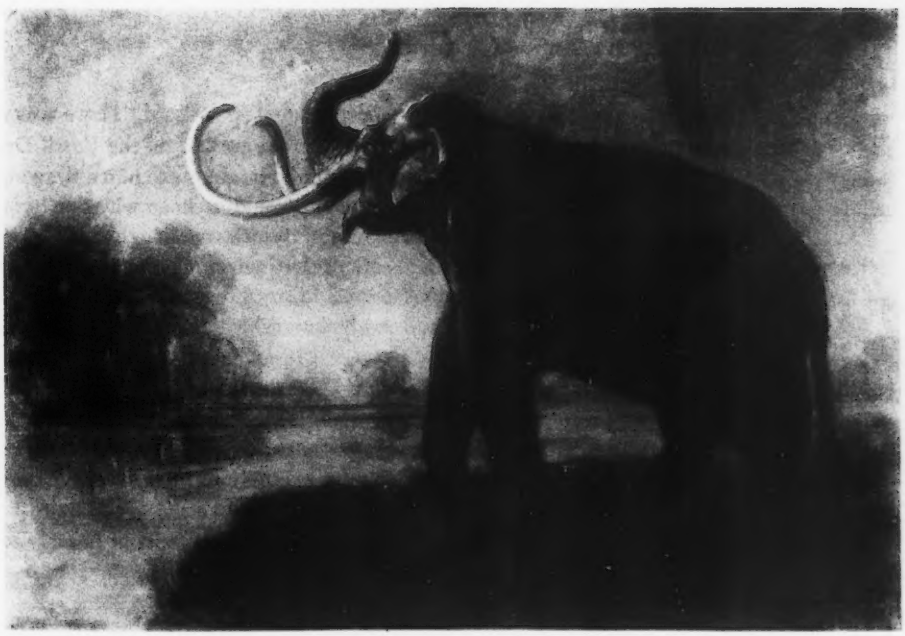

Fig. 15. The mammoth (Elephas columbi).

Fig. 16. Hoplophoneus, *a saber-tooth of Oligocene age.*

friends, so that one day when I entered the shop he said, 'There was a man named Dr. Wortman here yesterday, from upstairs in the Fossil Department, and he was looking for someone who might make him a drawing of a prehistoric animal. I said I believed you could do it, so why don't you go up and see him?' Thus, in the most prosaic way imaginable I was introduced to a set of men whose interest and encouragement eventually opened up for me a momentous period in my life work, and created a whole new field of research and study into which I could delve to my heart's content."

Henry Fairfield Osborn and William Diller Matthew were the two men most influential in shaping Knight's career. It was because of his readiness to work with these men, who were in command of many subtle details of animal anatomy and relationships, that his restorations brought convincing vitality to life long extinct.

"Prof. Osborn was something of a naturalist and an artist at heart, and had a great appreciation of all things living and beautiful."

Fig. 17. Dinictis, *a cat of Oligocene age, pursuing the herbivore* Protoceras.

"Dr. W. D. Matthew was a very profound student, a shy, humorous fellow and intensely interested in his subject. He fell in with our plans at once and for years was my chief consultant and adviser on matters of pose and difficult bone structure, and what such unusual forms might indicate in the living animal."

"For my part I strove to impart a life-like appearance to my restoration, certain that at one time the animal I had represented was a moving, breathing creature."

"Lions and tigers were always my favorites." The artist was fascinated by the grace and beauty of the great cats. He made numerous sketches of them from life, and his knowledge of feline anatomy and behavior, thus acquired, was applied to the restoration of many extinct cats.

Knight was especially interested in early man. Much of his attention, particularly in the later years of his life, was given to recreating scenes from the life of our immediate and collateral ancestors, who lived in a world dominated by mammoths, giant bears, woolly rhinoceroses, and

Fig. 18

many other mammals, long since extinct. His picture of Cro-Magnon men decorating the wall of a cave is justly famous.

Charles Knight was an artist of diverse talents. He worked in several media with a sure hand and an understanding eye. He drew small sketches and painted gigantic murals. He was an accomplished sculptor. His output was prodigious, and his drawings, paintings, murals, and sculptures can be seen in museums and other public buildings in North America. Many of his works are in private hands. During his later years he wrote and illustrated several books. At the end he could look back with satisfaction to his accomplishments of a half century and more, and could feel reassured that his had been a rich and full life.

Fig. 18. Cro-Magnon men.

Fig. 19. Knight painting the mammoth, in 1911 and in 1951.

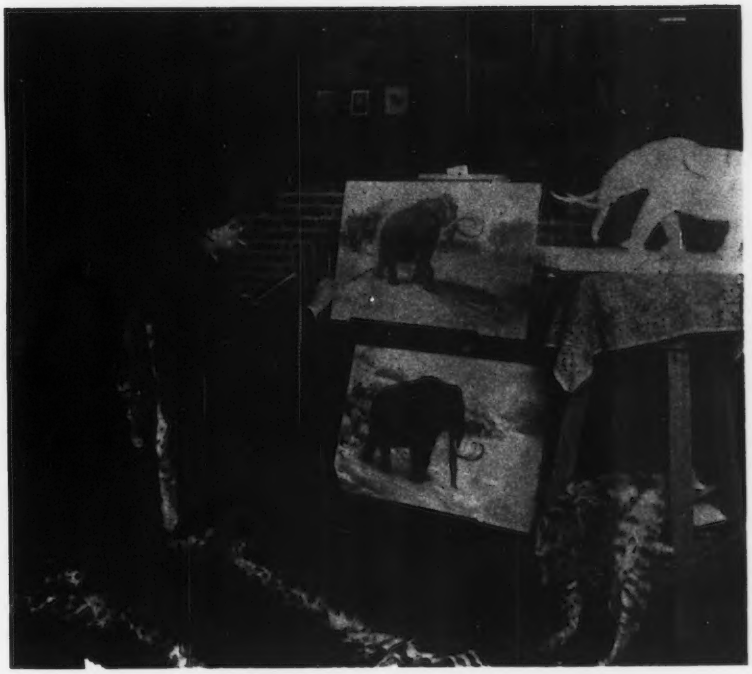

Fig. 19

Inexpensive Racks for the Storage of Large Specimens

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DEPARTMENT OF VERTEBRATE PALEONTOLOGY
THE AMERICAN MUSEUM OF NATURAL HISTORY

The storage of large specimens can be a vexing problem to the museum curator. Such specimens are, needless to say, bulky; they are often heavy; and they come in an unending assortment of odd shapes. By their very nature they are all too frequently the displaced elements in a systematically arranged storage area—thrust into odd corners, placed beneath tables, or consigned to the least desirable space at hand. They are the underprivileged members of the collection.

The types of racks for storing large museum specimens are almost as varied as the number of museums in which such objects are kept. Some institutions have well-constructed steel racks, furnished with large steel trays that slide in and out on rollers or bearings. Some have more modest adaptations of such an arrangement. Some have wooden racks, built on the spot. Some even have packing boxes, piled one on top of another. The variety of these facilities reflects to a large degree the funds or the lack of them available for the proper housing of collections.

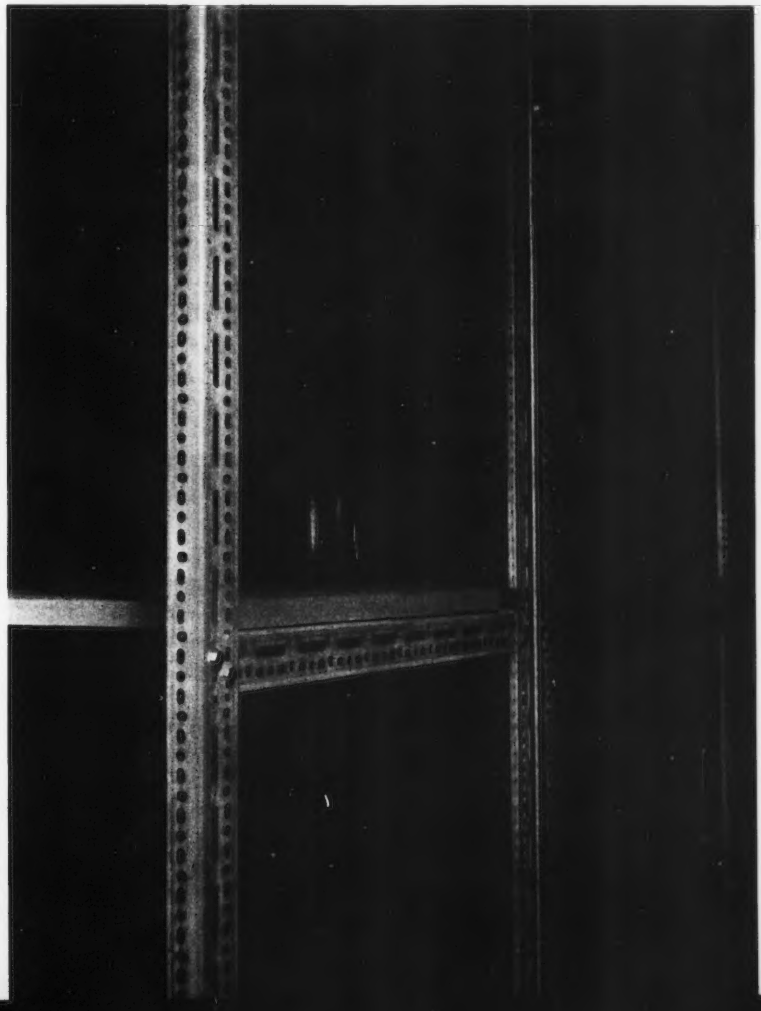
In these days of inflated costs, both for materials and for labor, the construction of adequate storage racks for large specimens can be a very serious drain on institutional funds. Indeed, such costs have been so

Fig. 1. A rack for the storage of large fossils. Note the diagonal members running longitudinally through the middle of the rack.

Fig. 2. Detail of rack, showing how the members are assembled and bolted together.

Fig. 1

Fig. 2



prohibitive in some institutions that the much-needed racks have never been provided, which, of course, is a negation of one of the prime functions of the museum.

Within the past few years The American Museum of Natural History has devoloped a type of storage rack for large specimens that affords a reasonably good compromise between excessive costs on the one hand and pinchpenny inferiority on the other. This rack, to be presently described, is not cheap, but it certainly is not expensive. Indeed, it is very likely about as inexpensive as is possible within the limits of good construction and strength. It was designed primarily for the storage of large, heavy fossils, but it might very well be adapted to many other uses.

In essence, the rack is built on the principle of steel toy construction sets, popular with small and medium-sized boys. The uprights and the horizontals consist of perforated structural steel, available under various trade names, such as Dexion, Metal Lumber, and Perma-Lock. The steel is manufactured in units of different lengths, six, eight, and ten feet and longer, at a cost to the purchaser of about thirty cents per foot. It can be cut to the dimensions required on the spot, with a hacksaw or with a special cutter designed for this purpose. The parts are bolted together, in the manner shown in the figures. It is not necessary to fasten the rack to the floor or to the ceiling, or even to a wall, because the structure is quite strong and sturdy. A large rack can be given additional rigidity by bolting diagonal struts into it, as shown in the figures.

The shelves consist of ordinary planking, sufficiently strong to hold the specimens.

The rack is very adaptable. Because everything is bolted together, it can be erected or taken down without the expenditure of much time or labor. The horizontal members can be shifted according to the needs of the moment, so that the rack can be adapted for very large or quite moderate-sized objects. In practice it has been found to be very strong, capable of supporting full-capacity loads of large fossils, each weighing many hundreds of pounds.

Of course this rack has one disadvantage; there are no nicely balanced trays on bearings to slide in and out. Heavy specimens must be eased onto the shelves with rollers, or they must be slid into place. But the advantages of the rack as regards its low cost and its adaptability to space are so great that they more than offset this one drawback.

Scuba[1] as an Aid to Archeologists and Paleontologists

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FLORIDA GEOLOGICAL SURVEY

Mechanically aided diving for archeological material is not of recent origin. Since the Korean War, numerous articles have appeared on the subject in both popular and scientific periodicals. These reports have described the fabulous finds in the cenotes of Yucatan and from the shallower waters of the Mediterranean. The earlier attempts at scientific collecting were made by hard-hat divers encased in fabric suits and wearing heavy lead-soled shoes. These divers were dependent on surface pumps for their air supply, and their movements were limited by the length and flexibility of their air hoses. Needless to say, much material was by-passed by these clumsy-suited men, who of necessity stirred up the mud and silt because they were bound to the bottom by the design of their equipment rather than able to swim suspended at any depth as is possible with scuba equipment.

The expense of the equipment and crew necessary for these earlier divers prohibited smaller institutions from engaging in under-water prospecting and collecting. A helmet diver needs costly dress, air hoses, and surface pumps, not to mention the handlers needed for his safety and comfort. Not so with a scuba diver. Such a venture can be a one-man (in shallow water) or at most a two-man operation, with both men actively engaged on the bottom. Complete freedom of movement is unknown to the diver who is dependent on a heavy suit and an umbilicus that links him with the dry world above. I recall that, in 1947, while working the bottom of the

[1] This term, usually printed in capital letters, is composed of the initial letters of the words Self Contained Underwater Breathing Apparatus. Common universal usage over the past decade argues for its general acceptance as a word.

Itchtucknee River in Florida aided by an open helmet, air hose, and pump, it was nearly impossible to keep my footing in the swift river channel. As my helmet shifted from the vertical, it filled with water and I had to surface, pull up the helmet, put it on again, and descend to try once more. In recent years I have had occasion to revisit some of these old localities equipped with modern self-contained gear and have found that I could work at any angle in perfect comfort and did not have to surface until I had collected all the vertebrate fossil material that had accumulated on the bottom.

Scuba is a fairly recent invention, dating back to World War II. The credit for this new means of getting below the surface of the water belongs to one man—Jacques-Yves Cousteau. He and Emile Gagnon developed the Aqua-Lung which is now manufactured and sold by the United States Divers Company of Santa Ana, California. This equipment has been widely tested and is in use by the United States Navy, as well as by many satisfied independent divers.

There is as much of a variety of skin-diving gear as there is in any equipment that is associated with a popular pastime. Face masks, flippers, and regulators have been designed to fit any taste or budget. The basic equipment needed by an archeologist or paleontologist to dive comfortably, prospect, and collect costs about the same as for a good set of golf clubs (Fig. 1). Basically the two-stage regulator is a combination of valves that allows highly compressed air to escape from a tank until it balances the surrounding water pressure. Air in turn is supplied to the diver on demand through his mouthpiece. The air tank is made of chrome molybdenum steel and holds between 1800 and 2250 pounds of air (not oxygen!) per square inch. A cylinder or bottle of air of this capacity will last about one hundred minutes at the surface, fifty minutes at a depth of thirty-three feet, and only twenty-five minutes at a depth of one hundred feet. The tank is supplied with a constant air reserve, or J valve, that can be activated by a release rod on the side of the tank when increased difficulty in breathing is noted. This will release the remaining one-eighth of the original air supply and allow a normal ascent to the surface. All apparatus is equipped with quick release fastenings in the event that it is necessary to get free of the lung. A carbon dioxide life ring is worn beneath all the equipment, which can be inflated to allow the diver to float on the surface with his head well out of the water if he were to become exhausted under emergency conditions.

Water that is colder than 70° F. can cause the loss of body heat to such a degree that exhaustion can take place within a relatively short time.

Fig. 1. Basic equipment used in under-water prospecting and collecting.

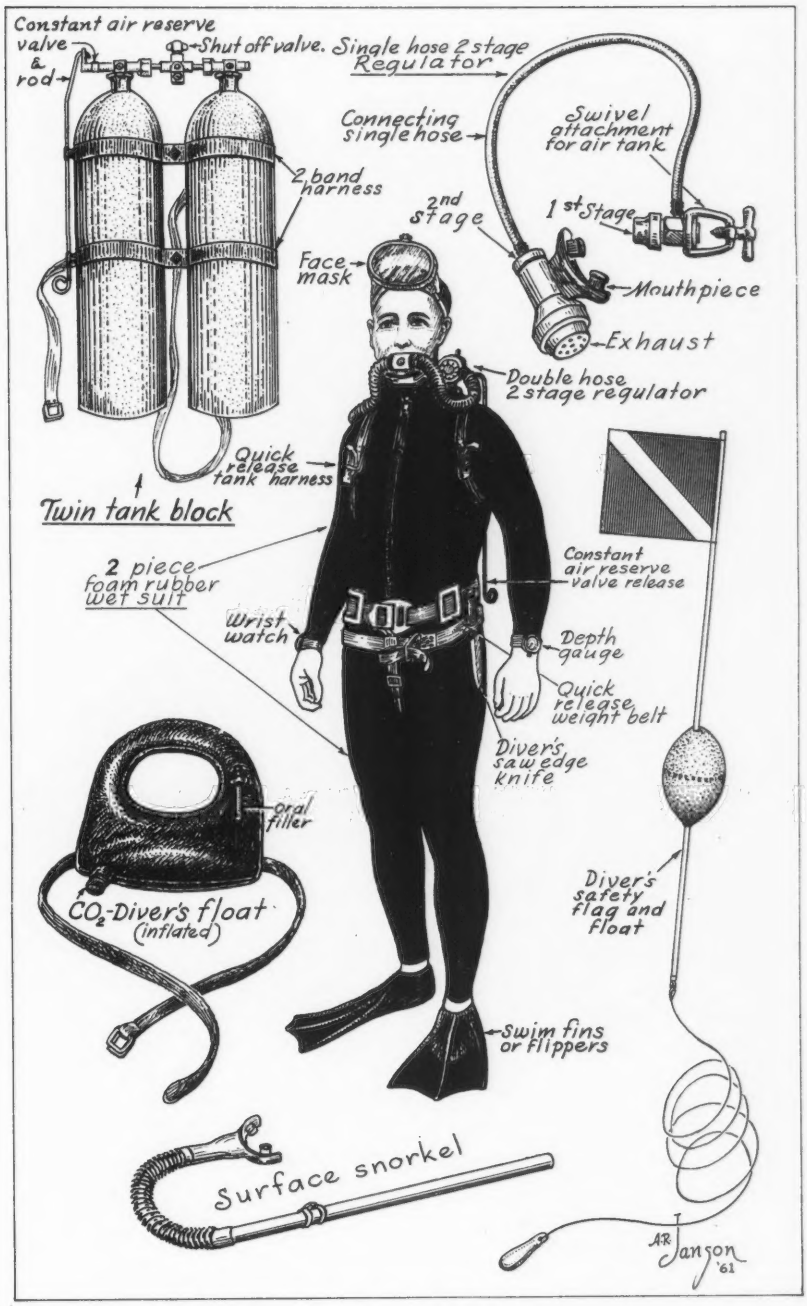
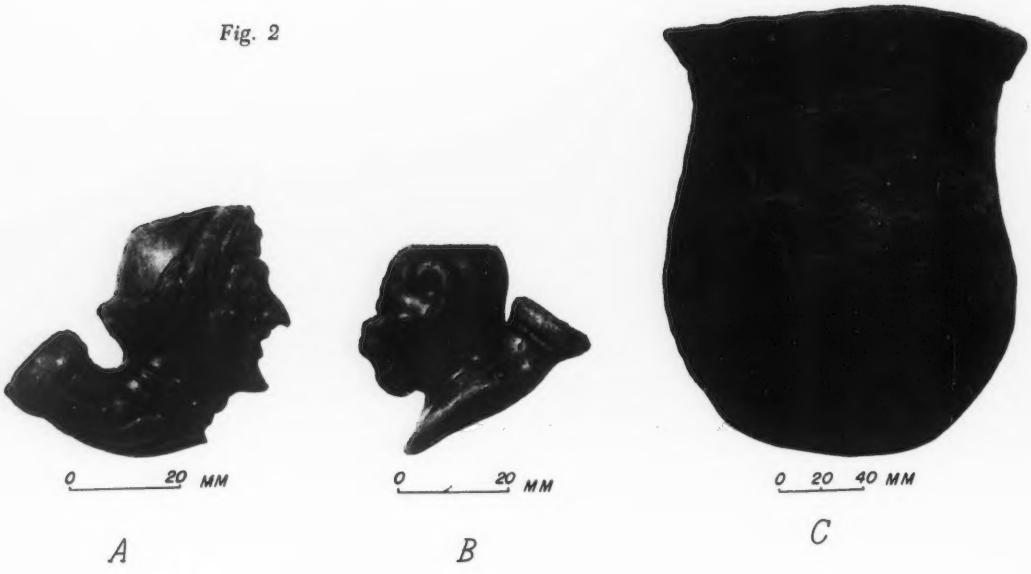

Constant air reserve valve & rod
Shut off valve.
Single hose 2 stage Regulator
Connecting single hose
Swivel attachment for air tank
2 band harness
2nd stage
1st Stage
Face mask
Mouthpiece
Exhaust
Double hose 2 stage regulator
Quick release tank harness
Twin tank block
2 piece foam rubber wet suit
Constant air reserve valve release
Wrist watch
Depth gauge
Quick release weight belt
Diver's sawedge knife
oral filler
CO_2 Diver's float (inflated)
Diver's safety flag and float
Swim fins or flippers
Surface snorkel
AR Janson '61

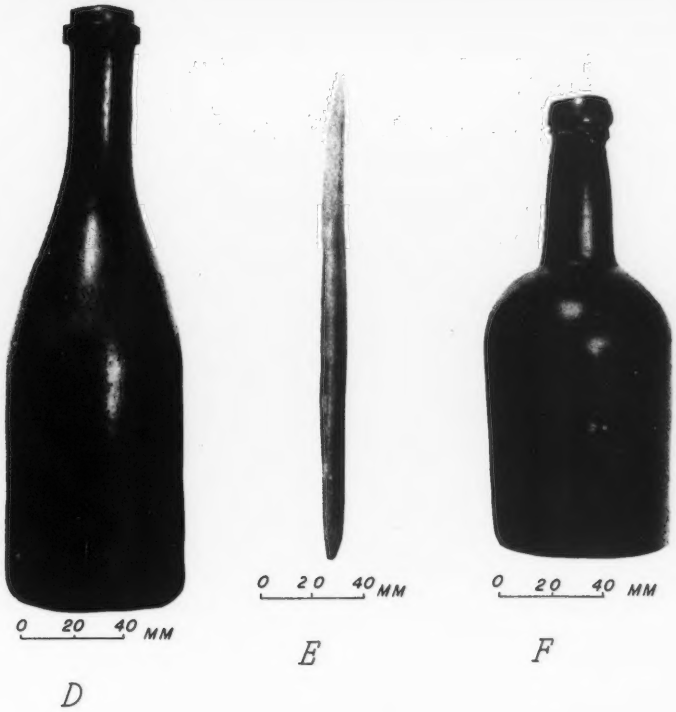
Fig. 1

Fig. 2



To overcome this hazard, several types of exposure suits are now available. The most popular is the standard two-piece wet suit. The principle of this dress is to allow a layer of water to seep beneath the garment so as to form a warm thermal layer between the foam Neoprene suit and the body of the diver. The other popular type of protective covering is the dry suit. This is a watertight garment which envelops the diver, who is clad in heavy underwear. If the suit leaks or is torn it is not only useless, but the waterlogged diver must get rid of this added weight before he can continue to dive.

The snorkel, mask, and fins can be used in very shallow water, and the snorkel can be an air saver in getting the diver to and from the boat and the diving site without using the air contained in his tank. If a locality is close to shore or if a boat can be used as a base, a "hookah," or gasoline-driven compressor, can be attached to the same two-stage regulator as that used with a tank. In place of a tank, a hose is secured to the first stage, so that it connects the diver to the surface air in much the same manner as for the deep-sea, hard-hat diver. However, the scuba-equipped prospector still has the advantage over his lead-soled counterpart in being able to swim above the silt or mud bottom and collect in much the same manner as when tank-equipped. But here again his activities are limited by the length and flexibility of his air hose. Several types of portable air compressors can be taken into the field and used to filter and recharge the diver's air tanks. Many parts of the United States have sporting goods stores that are also



compressor stations for scuba divers. They are particularly abundant in areas where year-around skin diving can be practiced. Many of these stations are listed in the magazines that are devoted to water sports. Tanks can be recharged for about $1.50 per tank.

If one is working at depths of thirty-five feet or less, the ascent is never accompanied by decompression troubles, no matter what length of time the swimmer has been under water (United States Divers Company, 1959). The lack of exhalation during a panicky ascent creates excessive pressure in the lungs. This condition has produced air embolism in less than fifteen feet of water (United States Navy, 1958). *Never hold your breath while ascending.* No one should attempt to dive unless he has had a thorough physical examination and has been checked out in full equipment by a qualified diver. Healthy, normal sinuses, middle ears, and lungs are essential for even short, shallow-water dives. Air trapped in a decaying tooth or beneath a loose filling will expand under pressure, as the diver surfaces,

Fig. 2. Fragile material, usually found broken on the land, is frequently encountered intact under water. A and B. Glazed pipe bowls from an early nineteenth century river town site in north Florida. C. Pre-Columbian vessel from the Aucilla River, Florida. D. Hand-finished, green glass, wine bottle from same locality as A. E. Point made from fossilized bone from Wakulla Springs, Florida. F. Hand-finished, black glass, rum bottle from same locality as A.

and can cause extreme pain. If a person familiarizes himself with the rules and practices the regulations set forth in the publications of the United States Navy Department (1958) and the United States Divers Company (1959), scuba diving can be less dangerous than driving a field car from New York to Wyoming.

Most under-water archeological and paleontological work in the Western Hemisphere is pure and simple salvage. The sites in which stratigraphic interpretations can be applied are nearly non-existent. Many villages and towns that border rivers and lakes used the adjoining waters as dumping grounds for their refuse. This material, which intermittently but steadily rained down to accumulate on the bottom, was in turn displaced and redeposited again in those areas where there is current action. In many rivers the accumulation of artifacts both ancient and recent has been gently rolled along the stream bottom to come to a final resting place in a natural depression. For example, an entire pre-Columbian vessel was collected from a hole in the bottom of the Aucilla River in north Florida (Fig. 2C). This fragile clay pot was nested in the limestone crypt beside a corroded flashlight, several beer cans, and a mastodon vertebra. This bizarre association does not detract from its cultural value even though, stratigraphically, it was not found "in situ."

Complete pots of this type are rare and are known from most surface sites only as small unassociated sherds. By the markings and temper of the materials that make up the vessel, its exact place in time and cultural association can be determined, particularly when fragments of similar pots are known from land sites in the immediate vicinity. Broken rum and wine bottles are present at nearly every early 1800 military site in Florida. Complete bottles from such a locality are virtually unknown. However, from the soft silt and sand bottom of the St. Marks River in north Florida several dozen complete green and black glass bottles have been recovered from an early nineteenth century town site (Fig. 2D and 2F). Broken stems and bowls of white clay pipes are turned up by the hundreds in the screening of a dry excavation, but rarely is a complete pipe encountered. In less than six hours diving I have collected more than thirty pipes, both white clay and glazed bowls, all from a depth of fifteen feet in one of Florida's swifter rivers (Fig. 2A and 2B). Heavy, water-logged, cypress, dugout canoes that would deteriorate in the humid soil of Florida are preserved intact on the river and lake bottoms, from which not a few have been salvaged.

Anyone who has tried to move a heavy fossil specimen from its resting place to a Jeep many yards away has more than once wished for an air-lift

Fig. 3. Objects that are too heavy to transport by hand can easily be moved under water by attaching air-filled bags and control lines.

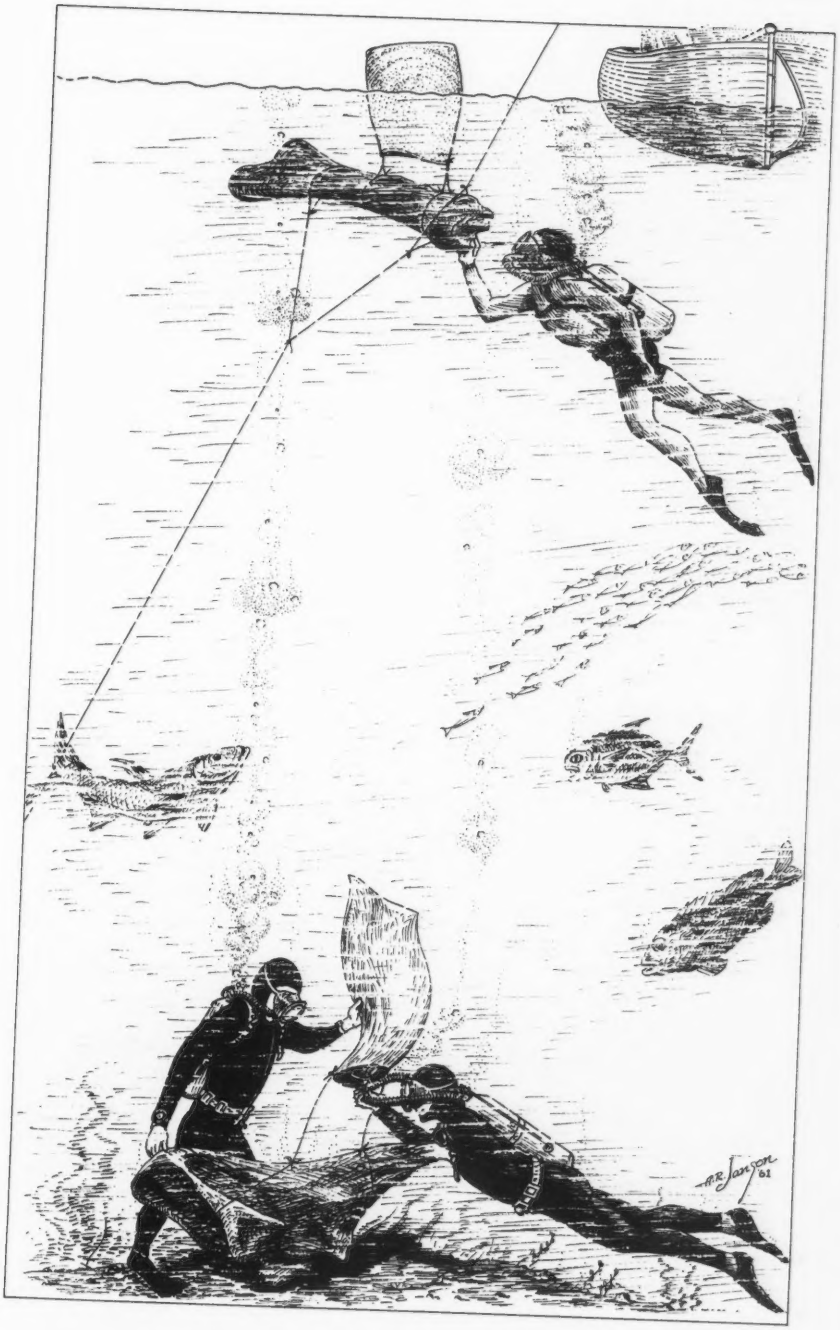


Fig. 3

to aid in this maneuver. Heavy bones are easily air-lifted from the bottom of springs and rivers many feet deep to a collecting boat on the surface (Fig. 3). No costly equipment is needed. A plastic-lined pillowcase is attached to the specimen and the bag is filled with air, either from the scuba mouthpiece (if double hose) or from an extra tank and hose that are taken below. Heavy Byzantine amphorae were brought up from one hundred and forty feet below the surface of the Mediterranean by inverting them, cleaning out the sand, and filling them with air from a hose connected to a surface compressor (Waterman, 1961). In guiding an air-buoyed object to the surface one must use care to spill out some of the air as the bag ascends. Expanding air increases the speed of the ascent and can cause breakage of the lifted object against the bottom of a salvage boat if not diminished.

Modified, portable, hand-controlled, California gold suckers have been used as aids in the collecting of small vertebrate remains where they have accumulated in large enough quantities (as in sinkholes) to warrant bringing in such equipment.

Recording under-water operations can be accomplished by the use of any of a wide variety of watertight housings for both still and movie cameras. Submarine lights, both battery and surface powered, are available for collecting in caves or areas where the natural light is inadequate for satisfactory under-water operations. Closed-circuit television and two-way telephones have also come into use in some instances where it was necessary to have direct communication between the surface and the scuba divers below.

In 1943 I applied for the Navy's diving school and felt at that time that the diving qualifications and restrictions were a bit too strict. I later learned that the type of training and the excellent safety record of the Navy divers were due to the initial regulations that did not allow for any and all to dive. Using scuba gear lulls one into a false sense of security, and many untrained people who purchase and use this equipment fail to realize the potential hazards or prepare themselves for the possibility of an under-water accident. Safely using the breathing apparatus means much more than just learning to breathe through a mouthpiece under water. The old saying, "a little learning is a dangerous thing," is particularly applicable to scuba diving.

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The Problem of Arrested Movement in Static Exhibits

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THE AMERICAN MUSEUM OF NATURAL HISTORY

The writer has long been intrigued by the question of how much "frozen action" the average viewer is able to accept in a museum exhibit without a loss of illusion, or even of faith in the integrity of presentation. It is a problem obviously calling for objective investigation by students of human behavior, and perhaps a few illustrations with some very broad generalizations based upon personal reactions may serve to stimulate a more adequate search for the factors and principles involved.

A habitat group in The American Museum of Natural History shows two Alaskan bull moose caught in a very dramatic but also very fleeting moment of battle. The animals may be viewed as a truly magnificent piece of sculpture—an outstanding example of a taxidermist's skills in the plastic art. But, when seen as part of the larger picture attempting to create an illusion of actual life persisting in a state of immobility, the postures of the embattled beasts have a quite disruptive effect in the eyes of many observers. The excellent museum of Malmö, Sweden, has boldly probed even farther beyond the safe limits of arrested movement contained within a static exhibit, in a diorama showing a cheetah in mid-air in its final leap upon a fleeing duiker antelope that also has all four feet off the ground. All museums should be grateful for the contribution such daring ventures make to our understanding of exhibition methods.

As a contrast with fighting moose and pouncing cheetah, we may consider the tense stalking of a hare by a Canada lynx in another habitat group in The American Museum of Natural History. This also has drama and conflict, but the sense of illusion is not strained by postures of movement that are hard to accept in immobility.

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Fig. 1. Fighting bull moose. The American Museum of Natural History.

Fig. 2. Cheetah and duiker antelope. Malmö Museum.

Fig. 3. Canada lynx stalking hare. The American Museum of Natural History.

Fig. 4. Wild asses. The Academy of Natural Sciences of Philadelphia.

From this comparison a very simple generalization would seem to suggest itself, namely, that complete illusion requires some sort of reasonable proportion between the length of time during which an aminal actually could hold the posture shown and the length of time it takes the visitor to register his impression of the entire exhibit in his mind.

But, at this point, we may recall some fine examples of skeletons immobilized in the midst of very fast action.[1] In these instances the arrested movement does not trouble the eyes or minds of the viewers. Obviously our generalization must be modified by taking into account the nature and purpose of the over-all exhibit in which the arrested movement is contained. The display of a skeleton in action is in itself a negation of illusion and therefore not subject to the requirements of deception. If we wish to illustrate by static exhibits the internal mechanics or external dynamics of fast animal action, it is therefore better to do so by the separate display of isolated specimens, whether whole or dissected, rather than trying to achieve the purpose by the incorporation of "frozen action" in the image of a natural setting striving for illusion.

Having reached this point in his reasoning, the writer felt fairly happy with his conclusions, vague though they were, until a new visit to the Academy of Natural Sciences of Philadelphia raised new doubts at the sight of a habitat group showing three wild asses running off towards the left front of the exhibit in a moderately vigorous manner. It would seem as though this immobile pretense should have weakened the impact of the display. But, in the writer's case at least, it did not. Perhaps this is due merely to personal idiosyncrasies, but perhaps also it may reveal a further refinement of the basic principles involved.

In the fighting moose and the leaping cheetah we are not only dealing with a speed of action that it would take a very fast camera to "stop" as the taxidermists have done, but also with a kind of action that would abruptly change its character within a fraction of a second. One moose is apparently on the verge of having a leg broken. The cheetah is about to land upon its victim and proceed to the kill. On the other hand, the three wild asses could easily keep on running in the same manner for quite a long time, although the momentary postures of each might be undergoing as rapid changes all the while as would those of the moose or cheetah if they were alive. It would therefore seem that an action which can be long sustained without change of its essential character fulfills the requirements for the display of arrested movement in a natural setting almost as readily as does a posture that can be long maintained.

[1] See Parr, "The Skeletons in the Museum," CURATOR, vol. III, no. 4, October, 1960, particularly fig. 6 on p. 302.

It also seems quite probable that a flock moving in unison may put less of a strain upon the sense of illusion than would a single animal arrested in exactly the same type of motion, or several animals immobilized in different and contrasting types of action. With the eye and the mind captivated by the image of the herd, which would present a relatively immutable picture even in life, the fleeting and varied postures of limbs and parts escape attention, or lose their sense of instability by integration into the more stable tableau of the flock. In Figure 4 one sees three wild asses on the run, but one does not pay attention to the individual positions and postures of twelve different legs, as one unavoidably notices all four legs of both cheetah and duiker antelope in Figure 2.

These comments are offered as personal observations only, in the knowledge that it is very important to learn where to "draw the line" in depicting nature by museum methods, and in the hope that others may add their own observations and conclusions to a discussion of how to show movement without motion.

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